AIRPLANE ENGINE MECHANICS

Questions and Answers

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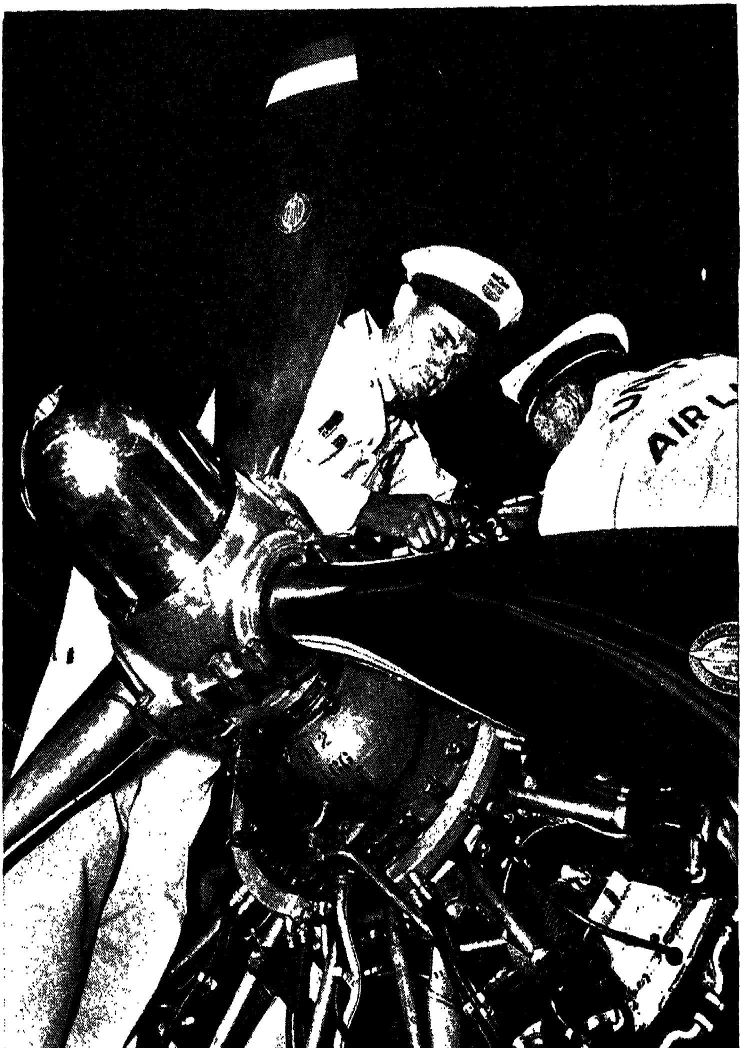

(United Airlines photograph.)

AIRPLANE ENGINE MECHANICS

Questions and Answers

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AIRPLANE ENGINE MECHANICS QUESTIONS AND ANSWERS

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PREFACE

This manual is prepared for the thousands of aircraft employees, mechanics, pilots, machinists, and all others in the vast army of production and operation workers in the aircraft industry today. Never before in the history of aviation was the need so great, and never were the opportunities more promising for the skilled aviation mechanic.

The questions in this manual assume that the reader is familiar with the fundamental principles of internal-combustion engines and their various accessories. It is not the intention of the writers fully to explain engine principles and basic physical laws, but to supply up-to-date information that is technically accurate and, at the same time, to acquaint the reader with a challenging situation such as will arise when he is confronted with the Civil Aeronautics Administration examination.

The questions are designed principally to aid in the preparation for obtaining a Civil Aeronautics Administration airplane-engine license. The authors wish to express their appreciation for helpful suggestions and important material supplied by the Civil Aeronautics Administration.

The multiple-choice type of examination as used by the Civil Aeronautics Administration is followed, and the contents are closely allied to the type of instruction given by the Army Air Forces technical training command and leading aviation ground schools of this country. A detailed explanation of the procedure to be followed in applying for a Civil Aeronautics Administration license is included.

The authors have compiled up-to-the-minute instruction in aircraft power-plant principles, maintenance, and procedure, to the exclusion of related subjects, such as sheet-metal work, riveting, fabric, etc. There are many admirable books deal-

ing with engine principles on the market, yet it is believed that some condensed preparatory information with each chapter will enable the reader to cope with the various questions, and to follow the sequence as it is presented.

Unless stated otherwise, all questions are based on the four-stroke cycle principle. In general, the material will deal with the direct air-cooled engine.

The authors have devoted considerable space to actual operation and maintenance, which of necessity will be treated in general rather than specific terms, as the emphasis is placed on the mechanic's having the requisite preparation and practice. This book should be of particular aid in conditioning the mechanic for the type and scope of the Civil Aeronautics Administration examination and enabling him to secure his engine license.

ROLLA HUBBARD,
AUGUSTIN DILWORTH.

NEW YORK,
March, 1944.

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AIRPLANE ENGINE MECHANICS QUESTIONS AND ANSWERS

CHAPTER I

CAA REGULATIONS AND PREPARATION FOR LICENSING ENGINE MECHANICS

Purpose of the Examinations.—The Civil Aeronautics Board requires that all persons who apply for mechanic's certificates or ratings must demonstrate their qualifications by satisfactory written and practical examination. This chapter deals only with the written examination. It has been prepared so that each applicant may know what is expected of him and so that he may become familiar with the form of the examination before he takes it.

Each examination is designed to test the applicant's understanding of the aeronautical knowledge necessary in the particular field in which he wants to be certified. The knowledge that each applicant should have is specified in the Civil Air Regulations and is discussed in the appropriate Civil Aeronautics bulletins. These examinations have a definite and a logical purpose. They are not designed to make it difficult for anyone to secure certificates and ratings or to prevent deserving persons from qualifying. The one purpose behind the whole testing program is *safety*.

The mechanic who works on an engine must know how to make adequate and safe repairs. Obviously, when there are thousands of applicants each year, the most desirable method for determining any applicant's competence is the method

that requires a minimum of his time and still gives a reliable indication of his qualifications. The written examination meets these requirements. The practical supervised examination, on the other hand, is the best method for determining an individual's ability.

How to Make Application.—Each person taking a written examination for a mechanic's certificate must fill out the correct application form. To find out when a representative of the CAA will be in your locality to give the examination, either inquire at your local airport or write to the regional manager of the Civil Aeronautics Administration in your region. The addresses of the regional offices are as follows:

Region 1. Post office box 336, La Guardia Field, New York, N.Y.

Region 2. Municipal Airport, Atlanta, Ga.

Region 3. 608 South Dearborn Street, Chicago, Ill.

Region 4. Post office box 1689, Fort Worth, Tex.

Region 5. Ninth Floor, City Hall Building, Kansas City, Mo.

Region 6. 1508 Fourth Street, Santa Monica, Calif.

Region 7. Smith Tower, annex, Seattle, Wash.

The regional manager will send you the schedule for written examinations from which you can determine when and where examinations will be given in your locality.

Eligibility.—The following is taken from Part 24 of the Civil Air Regulations.

Part 24.1. Mechanic's certificate requirements

To be eligible for a mechanic's certificate, an applicant shall comply with the following requirements:

Part 24.10. *Age.*—Applicant shall be at least eighteen years of age.

Part 24.11. *Character.*—Applicant shall be of good moral character.

Part 24.12. *Citizenship.*—Applicant shall be (*a*) a citizen and of unquestionable loyalty to the United States, or (*b*)

a person who is in sympathy with the objectives of the United States and who is a trustworthy citizen of a friendly government not under the domination of or associated with any government with which the United States is at war.

Part 24.13. *Education.*—Applicant shall be able to read, write, speak, and understand the English language: *provided, however*, that this requirement shall not apply to an applicant employed by an air carrier outside the United States, and that airmen rating records issued to such applicants as may be unable to read, write, speak, or understand the English language shall bear the following notation: (*valid* only outside the United States while employed by an air carrier).

Part 24.14. *Other Requirements.*—Applicants shall comply with the requirements prescribed in this part for the particular mechanic rating sought.

Part 24.2. *Mechanic Ratings.*—Mechanic ratings are as follows: (*a*) aircraft mechanic rating, (*b*) aircraft-engine mechanic rating, (*c*) parachute rigger rating, (*d*) factory mechanic rating.

Part 24.21. *Aircraft-engine Mechanic Rating.*—To be eligible for an aircraft-engine mechanic rating an applicant shall comply with the following requirements:

Part 24.210. *Aeronautical Knowledge.*—Applicant shall have theoretical and practical knowledge of aircraft power plants, propellers, and their appliances; shall know how properly to inspect, maintain, and repair the same; and shall be generally familiar with the provisions of Parts 04, 13, and 14, and thoroughly familiar with the provisions of Part 01 dealing with aircraft airworthiness and the provisions of Parts 18 and 24.

Part 24.211. *Aeronautical Experience.*—Applicant shall have had at least one year of practical experience, or what is deemed by the administrator to be its equivalent, in the construction, inspection, maintenance, or repair of aircraft engines, propellers, and their appliances.

Part 24.212. *Aeronautical Skill.*—Applicant shall satisfactorily demonstrate by means of written, oral, and practical test, his ability with respect to the subject matters prescribed in Part 24.210.

Part 24.30. *Application.*—Application for a mechanic's certificate shall be made upon the application form prescribed and furnished by the administrator.

Part 24.31. *Display.*—A mechanic's certificate shall be kept readily available to the mechanic at all times when he is serving in connection with certified aircraft, aircraft engines, propellers, and appliances. It shall be presented for inspection upon the reasonable request of any person.

Part 24.32. *Duration.*—A mechanic's certificate shall be of 60 days' duration, and unless the holder is otherwise notified by the administrator within such period, it shall continue in effect thereafter until otherwise specified by the board, unless suspended or revoked.

Part 24.34. *Nontransferability.*—A mechanic's certificate is not transferable.

Part 24.35. *Surrender.*—Upon the suspension, revocation, or expiration of a mechanic's certificate, the holder thereof shall surrender such certificate, upon request, to any officer or employee of the administrator.

Part 24.36. *Reexamination.*—An applicant for a mechanic's certificate or rating who has failed to accomplish successfully any prescribed theoretical or practical examination or test may apply for reexamination at any time after the expiration of 30 days from the date of such failure.

Part 24.38. *Revocation.*—No person whose mechanic's certificate has been revoked shall apply for or be issued a mechanic's certificate of any rating for a period of one year after the revocation, except as the order of the revocation might otherwise provide.

Part 24.40. *General.*—The examinations and tests prescribed in this part will be conducted by an authorized representative of the administrator.

Part 24.41. *Time and Place.*—All examinations and tests will be held at such times and places as the administrator or his representative may prescribe.

Part 24.42. *Inspection.*—The applicant for a mechanic's certificate or rating shall offer full cooperation with respect to any inspection and examination that may be made of such applicant upon proper request by an authorized representative of the administrator prior or subsequent to the issuance of a mechanic's certificate or rating.

Part 24.43. *Standard of Performance.*—All practical or theoretical examinations and tests shall be accomplished to the satisfaction of the administrator, and the passing grade in each subject of examination or test shall be at least 70 per cent.

Part 24.50. *Airmen Rating-record Requirement.*—A certificated mechanic who is directly in charge of packing parachutes or of the inspection, maintenance, or repair of certificated aircraft, aircraft engines, or their appliances shall not engage in such service unless there is attached to his certificate the appropriate airmen rating record, prescribed and issued by the administrator. Every holder of a valid mechanic's certificate, or parachute rigger certificate, in effect on May 1, 1940, may perform service pursuant to such authority without an airmen rating record until the expiration, suspension, or revocation of such license or certificate.

Part 24.54. *Mechanic Identification Card.*—No person shall serve as a mechanic in connection with the inspection, maintenance, overhaul, or repair of aircraft engines, propellers, or appliances thereof, or as a parachute rigger, after June 15, 1942, unless he has in his possession, in addition to a currently effective mechanic's certificate, an identification card, satisfactory to the administrator, containing his fingerprints, his picture, and his signature.

Part 24.55. *Recent Experience Requirements.*—The holder of a mechanic's certificate shall not exercise the privileges thereunder, unless within the preceding 24 calendar months

he has (*a*) served as a mechanic under the terms of his certificate and rating for at least 6 months of such 24-month period, (*b*) demonstrated to the satisfaction of the administrator that he is able to meet the standards currently prescribed by the Civil Air Regulations for the issuance of the certificate and rating.

Part 24.56. *Reports.*—The holder of a mechanic's certificate shall transmit to the administrator annually, during the month of January, a report for the preceding 12-month period, setting forth the amount and type of his aeronautical experience and such other pertinent data as the administrator may require.

Part 24.57. *Expired Certificates: Special Issuance.*—The holder of a mechanic's certificate that has expired during the preceding 12 months may obtain a new certificate and the same rating theretofore held immediately prior to its expiration, upon application, by demonstrating to the satisfaction of the administrator that he is able to meet the standards currently prescribed by the Civil Air Regulations for the issuance of the certificate and rating.

What to Study.—An applicant for a mechanic's certificate should be familiar with the following list of bulletins, issued by the Civil Aeronautics Bureau, pertaining to the engine mechanic only. This literature may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C.

Civil Air Regulations.

1. Manuals	04	Airplane Airworthiness.
2. Manuals	18	Maintenance, Repair and Alteration of Certificated Aircraft and of Aircraft Engines, Propellers and Instruments.
3. Parts	01——	Airworthiness Certificates.
4. Parts	13——	Aircraft Engine Airworthiness.
5. Parts	14——	Aircraft Propeller Airworthiness.

6. Parts 18—— Maintenance, Repair and Alteration of Certificated Aircraft and of Aircraft Engines, Propellers and Instruments.
7. Parts 24—— Mechanic Certificates.

How to Study for Examination.—The mechanics' written examinations are designed to determine whether an applicant's understanding of aeronautical knowledge is adequate to enable him to undertake with safety the responsibilities conferred upon him under the terms of the certificate or rating he is seeking. There are certain fundamentals that every mechanic must understand thoroughly in order to be a good, safe mechanic. If an applicant knows these things and passes the written examination solely by relying upon his complete understanding of the necessary aeronautical knowledge, he can be confident that he is qualified to fulfill the obligations of his certificate or rating. If an applicant does not know these fundamentals thoroughly and attempts to make up for his lack of knowledge by cramming (memorizing facts without understanding them) or by using unethical methods in answering questions, he cannot be sure that he is competent to meet the requirements of the certificate sought, even though he may pass the examination. Situations are likely to arise with which he will be unable to cope. Such an applicant is headed for accidents or violations. He should always remember that it is better to fail in an examination on the first attempt and so discover his deficiencies, correct them, and become a safe mechanic, than to pass on the first attempt in spite of deficiencies in aeronautical knowledge that would always be a handicap.

Studying the various topics outlined here will give a better perspective and a clearer understanding of the subject matter. Discuss the things you do not understand with your instructor, your friends, experienced mechanics with whom you are acquainted, and with other students who are preparing them-

selves for this particular examination. By discussing with other individuals the things that are not entirely clear to you, you will often be able to clear up misunderstandings and improve your comprehension of the material. Put into practice the things that you learn from books and manufacturers' manuals and this will develop your understanding and fix these ideas clearly in your mind.

How to Take the Examination.—Always bear in mind the following facts while you are taking the examination. The questions are not trick questions. Each statement means exactly what it says. Do not look for hidden meanings. The statement does not concern exceptions to the rule. It refers to the general rule. In the case of a multiple-choice question always read the statement or question first before you look at the several answers given, from which you are to choose. Be sure that you understand what is meant. Think of the correct answer. Finally, look through the list of alternate answers or phrases and find the one that says the same thing as your own answer. Be sure that the one you select answers the question completely. Remember, only one of the alternate answers given is completely correct. The others may be correct only under certain conditions or may be answers that result from incorrect procedure. For example, suppose that the following question (question 35) were to appear on your examination:

35. When a valve clearance is being checked on a radial aircraft engine, the piston should be

a. on bottom center of the intake stroke
b. on top center of the exhaust stroke
c. on bottom center of the power stroke
d. on top center of the compression stroke

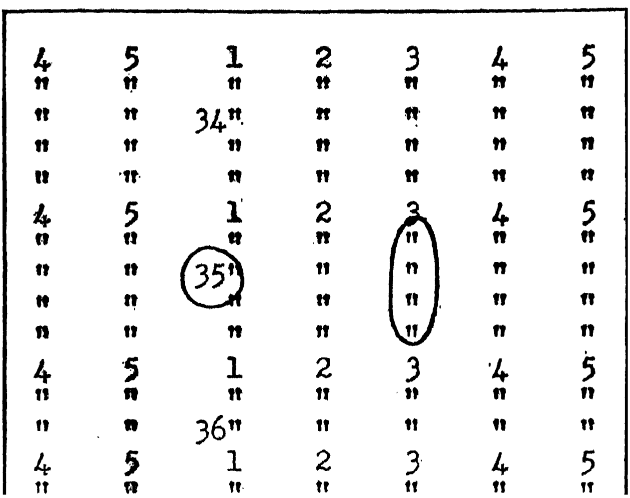
In choosing the correct answer, remember that both valves should be closed when valve clearances are being adjusted. In answer *a* the intake valve is still open at the bottom of the stroke, eliminating *a* as the possible answer. In answer *b* we know that the exhaust valve is still open on the exhaust stroke,

eliminating *b* as the possible answer. In answer *c* we know that the exhaust valve starts to open before the piston reaches bottom dead center, eliminating *c* as the possible answer. In answer *d* we know that both valves must be closed at the start of the compression stroke; therefore, both valves being closed, *d* is the correct answer.

A picture of a small section of the special answer sheet that may be given you when you take the examination follows. Your answer to question 35 above would be recorded in the following manner:

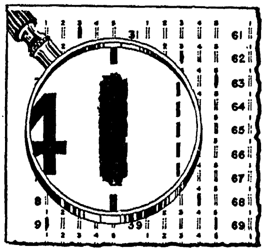
1. Find the row on the answer sheet numbered the same as the question you are answering (in this case row 35).

2. In this row find the pair of dotted lines numbered the same as the answer that you consider correct for the question (in this case pair of lines *d*). Let us give the letter *d* the number 3, to enable us to use the following table. Assuming that No. 3 is the correct answer, blacken out that answer space, that is, draw a heavy vertical line between these two dotted lines with the special pencil provided or with a soft lead pencil, preferably a No. 2 pencil. The guide number of the correct

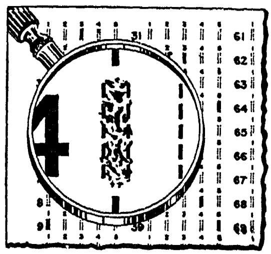


row and the guide number of the correct pair of lines have been circled in the illustration of the special answer sheet on page 9.

Since the pencil mark on the answer sheet must contact an electrical current in order to be scored by the electric scoring machine, the pencil mark must be a *solid black pencil mark.* Solid black marks are made by using a soft-lead pencil. The following illustration shows satisfactory and unsatisfactory marks:



Satisfactory



Unsatisfactory

Complete directions indicating how you should answer the questions and how your answers should be recorded on the special answer sheet are printed on the back of the cover page for each mechanic's examination you will take. If you find that you have much difficulty with any of the questions, do not spend too much time on them. Pass on to the ones you are sure of. Simply omit the ones you have not answered and come back to them later. The questions need not be answered in order. Do as many as you can. In that way, you will give the best indication of how much you know.

If you remember these facts and follow the instructions given in this chapter and if you also benefit by practice in finding the solutions to the type of questions in the following chapters of this book, put there for the express purpose of helping to prepare you for your mechanic's certificate, you will certainly be repaid with a higher final test score.

MULTIPLE-CHOICE QUESTIONS*

1. Which certificate is void, if the owner of an aircraft is found to be a citizen of a foreign power?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

2. Which certificate could be canceled if the owner of an aircraft made a formal request for cancellation?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

3. Which certificate will expire when the aircraft is sold?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

4. Which certificate will be issued only after an aircraft has successfully passed inspection?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

5. Which certificate, after sale of an aircraft, is transferable for a certain time, then expires?

a. airworthiness
b. registration
c. neither

* A key to the answers is given on p. 22.

d. both
e. mechanic's

6. Which certificate will be issued only after the holder successfully passes examinations by CAA?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

7. Which certificate must be reindorsed at the end of a specifically designated period, that is, usually 1 year?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

8. Which certificate is accompanied by the aircraft operations record?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

9. Which certificate must be reindorsed at the end of a specifically designated period, that is, usually 2 years?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

10. Which certificate is accompanied by the airman's rating record?

a. airworthiness
b. registration
c. neither
d. both

e. mechanic's

11. Which certificate requires that the holder must have had at least 1 year of practical experience?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

12. Which certificate does not have to be displayed in the aircraft?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

13. For which certificate is form 501 made out?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

14. For which certificate is form 305 made out?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

15. For which certificate is form 348 made out?

a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

16. For which certificate is form 500 made out?

a. airworthiness
b. registration

c. neither
d. both
e. mechanic's

17. For which certificate is form 308 made out?
a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

18. Which certificate will be revoked if a major repair or alteration is not passed by a CAA inspector?
a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

19. Which certificate will be void if an aircraft has not been test flown following a major repair, if the aircraft is to carry passengers?
a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

20. Which certificate will be revoked if the holder is found to possess narcotics while holding the certificate?
a. airworthiness
b. registration
c. neither
d. both
e. mechanic's

21. Who is permitted by CAR to weld aluminum oil or fuel lines?
a. a certificated mechanic
b. certificated repair station and manufacturer

c. the manufacturer only
d. no one

22. Who is permitted by the CAR to weld a crankcase section of the aircraft engine?

a. a certificated mechanic
b. certificated repair station and manufacturer
c. the manufacturer only
d. no one

23. Who is permitted by the CAR to make minor alterations on engine instruments?

a. a certificated mechanic
b. certificated repair station and manufacturer
c. the manufacturer only
d. no one

24. Who is permitted by the CAR to make major alterations on propellers?

a. a certificated mechanic
b. a certificated repair station and manufacturer
c. the manufacturer only
d. no one

25. Who is permitted by the CAR to make alterations on propeller hubs?

a. a certificated mechanic
b. certificated repair station and manufacturer
c. the manufacturer only
d. no one

26. Who is permitted by the CAR to make a top overhaul on an engine of 225 hp.?

a. a certificated mechanic
b. certificated repair station and manufacturer
c. the manufacturer only
d. no one

27. Who is permitted by the CAR to make a complete overhaul on an engine of 275 hp.?

a. a certificated mechanic
b. certificated repair station and manufacturer

c. the manufacturer only

d. no one

28. Who is permitted by the CAR to make a complete overhaul on an engine of 175 hp.?

a. a certificated mechanic

b. certificated repair station and manufacturer

c. the manufacturer only

d. no one

29. Who is permitted by the CAR to make minor alterations on a certificated aircraft engine?

a. a certificated mechanic

b. certificated repair station and manufacturer

c. the manufacturer only

d. no one

30. Who is permitted by the CAR to make minor alterations on propellers?

a. a certificated mechanic

b. certificated repair station and manufacturer

c. the manufacturer only

d. no one

31. Who is permitted to anneal copper oil or copper fuel lines after they have been bent to shape?

a. a certificated mechanic

b. certificated repair station and manufacturer

c. the manufacturer only

d. any of the above

32. Who is permitted to make alterations on aircraft instruments?

a. a certificated mechanic

b. a certificated repair station and manufacturer

c. the manufacturer only

d. no one

33. A vacuum gauge is

a. required on every engine

b. required only if the engine is supercharged

c. not required

d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used

34. A means of indicating the head temperatures of the engine is
a. required on every engine
b. required only if the engine is supercharged
c. not required
d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used

35. Dual ignition is
a. required on every engine above 100 hp.
b. required only if the engine is supercharged
c. not required
d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used

36. A hydraulic pump is
a. required on every engine
b. required only if the engine is supercharged
c. not required
d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used

37. A fire-extinguisher ring is
a. required on every engine
b. required only if the engine is supercharged
c. not required
d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used

38. A booster pump is
a. required on every engine
b. required only if the engine is supercharged
c. not required
d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used

39. A tachometer is
a. required on every engine
b. required only if the engine is supercharged

c. not required
d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used
40. A two-position pitch control is
a. required on every engine
b. required only if the engine is supercharged
c. not required
d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used
41. A manifold pressure gauge is
a. required on every engine
b. required only if the engine is supercharged
c. not required
d. required only when a constant-speed propeller is used
e. required only when a controllable propeller is used
42. The expansion space in an oil tank must be
a. at least 10 per cent of total tank volume—not less than ½ gal.
b. at least 5 per cent of total tank volume—not less than ½ gal.
c. at least 20 per cent of total tank volume—not less than 1 gal.
d. at least 15 per cent of total tank volume—not less than 1 gal.
e. at least 10 per cent of total tank volume—not less than 1 gal.
43. When should a periodic inspection be made?
a. after 25 hr. of flying time
b. after 50 hr. of flying time
c. after 75 hr. of flying time
d. after 100 hr. of flying time
e. after 200 hr. of flying time
44. When should a daily inspection be made?
a. after 25 hr. of flying time
b. after 50 hr. of flying time
c. after 75 hr. of flying time

d. after 100 hr. of flying time
e. after 200 hr. of flying time

45. After an engine overhaul, the engine should be
a. "run in" according to CAR
b. "run in" according to the amount of time on the engine
c. "run in" according to the manufacturer's instructions
d. given a breakdown test
e. crated

46. The oil capacity of a lubrication system should not be less than
a. 1 gal. of oil to 10 gal. of gas
b. ½ gal. of oil to 25 gal. of gas
c. 2 gal. of oil to 20 gal. of gas
d. ½ gal. of oil to 10 gal. of gas
e. 2 gal. of oil to 50 gal. of gas

47. Any structural part used to repair an engine must be
a. as per specification
b. exact duplicate of original and approved by the administrator
c. heat-treated
d. entered in the logbook
e. hardened according to the manufacturer's specifications

48. When making an entry of a minor repair in the logbook, you must include
a. mechanic's name and address
b. name of the approved repair station
c. drawings of the repair
d. the date the repair was started, and the date the repair was finished
e. the signature and certificate number of the mechanic who made the repair, or who was in charge of the repair

49. What is the minimum clearance allowed by the CAR between the propeller tip and the ground?
a. 6 in.
b. 9 in.
c. 12 in.

d. 18 in.
e. 24 in.

50. What is the minimum clearance allowed by the CAR between the propeller tips and the water on a seaplane?

a. 6 in.
b. 9 in.
c. 12 in.
d. 18 in.
e. 24 in.

ESSAY-TYPE QUESTIONS*

51. Should a certificated engine mechanic be experienced in the maintenance of ignition systems?

52. If you fail in this examination, when may you reapply?

53. What are the grounds for suspension or revocation of a mechanic's certificate?

54. What is the passing grade for an engine mechanic's certificate?

55. Where should the logbook of a certificated aircraft be kept?

56. May a licensed aircraft or engine mechanic do instrument minor repairs?

57. What are considered minor alterations on aircraft engines?

58. Where must a mechanic keep his certificate?

59. What is engine routine maintenance?

60. May a certificated engine mechanic ride in the copilot's seat?

61. May a citizen of a foreign country hold a mechanic's certificate?

62. What are the qualifications for a factory mechanic's rating?

63. Is a compass ever required on a certificated aircraft?

64. What is the duration of a mechanic's license?

65. Define propeller minor alterations.

* Answers are given on p. 22.

66. What engine instruments are required on a certificated aircraft?

67. What requirements must be met before carrying passengers for hire in an aircraft that has been damaged?

68. Who may do minor repairs or minor alterations on a certificated aircraft?

69. Is a mechanic's certificate transferable?

70. How often must a certificated aircraft be inspected?

71. Who may do major alterations and major repairs on aircraft propellers?

72. What lights must be carried on an airplane carrying passengers for hire at night?

73. May an uncertificated mechanic work on a certificated aircraft?

74. Does an airplane have to be flight tested if it has undergone a maintenance minor repair or minor alteration?

75. Are safety belts required on all certificated aircraft?

76. May anyone except a certificated mechanic sign a logbook for a certificated aircraft?

77. How must minor-repair alterations be entered in the logbook?

78. What must be the aeronautical knowledge of an applicant for a mechanic's license?

79. What is the inspection on wooden propellers?

80. State the defects that would cause wooden propellers to be rejected for use on a certificated aircraft.

81. What is the treatment of minor surface defects on a metal propeller?

82. What are repair agencies?

83. What is meant by a periodic inspection?

84. What persons are authorized to make a periodic inspection?

85. What must be the aeronautical experience of an applicant for a mechanic's certificate?

86. What are the requirements relative to placarding the baggage compartment on a certificated aircraft?

87. Name the proper procedure for safetying an engine-control turnbuckle.

88. Must a mechanic have an identification card?

89. What rule governs the mechanic in the repair of certificated engines?

90. What is meant by a certificated mechanic?

91. May a certificated mechanic work on an uncertificated aircraft?

92. Who may repair a hollow or steel propeller?

93. Who is authorized to make a line inspection?

94. Can the crankshaft of an aircraft engine in an airplane that has nosed over be repaired?

95. Can cotter pins and safety wire be used over?

96. After an aircraft engine has been overhauled, should it be run in?

97. On certificated aircraft carrying passengers for hire, what are the safety requirements?

98. What entries are required in the airplane engine log?

99. What special equipment must be kept in a certificated aircraft making a flight over water?

100. What minimum tip clearance is required on propellers of landplanes, seaplanes?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 11

1. *b*	2. *d*	3. *b*	4. *a*	5. *b*	6. *e*
7. *a*	8. *a*	9. *e*	10. *e*	11. *e*	12. *e*
13. *b*	14. *a*	15. *e*	16. *b*	17. *a*	18. *a*
19. *a*	20. *e*	21. *d*	22. *d*	23. *b*	24. *b*
25. *b*	26. *a*	27. *a*	28. *a*	29. *a*	30. *a*
31. *d*	32. *b*	33. *c*	34. *c*	35. *a*	36. *c*
37. *c*	38. *d*	39. *a*	40. *e*	41. *b*	42. *a*
43. *d*	44. *a*	45. *c*	46. *d*	47. *b*	48. *e*
49. *b*	50. *d*				

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 20

51. Yes, a certificated mechanic should be experienced in the maintenance of ignition systems.

52. If you fail in this examination, you may reapply at any time after the expiration of 30 days from the date of such failure.

53. Some of the grounds for suspension or revocation of a mechanic's certificate are as follows: Refusal to exhibit certificate on proper demand. Any demonstration of incompetency in the construction, repair, adjustment, or overhaul of aircraft, or aircraft engines, or in the inspection of construction, repair, adjustment, or overhaul thereof. Being under the influence, or using, or having personal possession of any intoxicating liquor, cocaine, or other habit-forming drugs while on duty. Any false statement in the application for certificate or in any report required by the secretary. Using or displaying the certificate for any fraudulent purpose. Violation of any provisions of the Air Commerce Act or of any of the rules or regulations duly issued thereunder.

54. The minimum passing grade for a mechanic's certificate is 70 per cent.

55. The logbook of a certificated aircraft should be kept in the aircraft at all times when it is away from the landing area regularly used as its base of operations, provided, however, that logbooks for certificated air-line aircraft may be maintained and kept at terminals.

56. All repairs should be done at an instrument repair station. An A & E mechanic may only take out and install the instruments. There is yet no rating for instrument men, just a station certificate. Minor repairs are classed as cleaning, adjustment, or replacement of parts in instruments.

57. The alteration or conversion of an aircraft engine by replacement or addition of parts, in compliance with Airworthiness, Maintenance Inspection Notes, listed on the engine specifications issued by the Civil Aeronautics Administration or in accordance with the Administrator of Civil Aeronautics Approved alteration instructions of the manufacturer of the aircraft engine is considered a minor aircraft-engine alteration.

58. A mechanic's certificate shall be kept readily available to the mechanic at all times when he is serving in connection with certificated aircraft, aircraft engines, propellers, or appliances, or parachutes, and shall be presented for inspection upon the reasonable request of any person.

59. Routine maintenance is defined as simple or minor preservation, operations including, but not limited to, the adjustment of rigging and clearances, and the replacement of small standard parts not involving complex assembly operations, such as changing spark plugs, cleaning ignition points, setting valve clearances, and cleaning screens.

60. Yes, a certificated engine mechanic may ride in the copilot's seat.

61. Yes, a citizen of a foreign country may hold a mechanic's certificate—any person who is in sympathy with the objectives of the United States and who is a trustworthy citizen of a friendly foreign government not under the domination of or associated with any government with which the United States is at war.

62. To be eligible for a factory mechanic's rating, the applicant must be employed by and designated by a manufacturer holding a currently effective production certificate, as in direct charge of the inspection, maintenance overhaul, or repair of aircraft, aircraft engines, propellers, or instruments constructed by such manufacturer. The experience and employment record of the applicant must indicate that he is competent to engage in such activities.

63. Yes, when flying over a body of water out of sight of land, or when flying more than 100 miles from the base of operation.

64. A mechanic's certificate shall be of 60 days' duration and, unless the holder is otherwise notified by the administrator within such period, it shall continue in effect thereafter until otherwise specified by the board, unless suspended or revoked, provided that a factory mechanic's rating shall terminate at any time that the holder thereof ceases to be

employed by the manufacturer to whose products the rating is limited or whenever the facilities of such manufacturer are no longer available to or in use by the holder.

65. Changes on propeller hubs or propeller governors made in compliance with "Airworthiness, Maintenance Inspection Notes," which supplement the propeller specifications issued by the Civil Aeronautics Administration, or in accordance with Administrator of Civil Aeronautics Approved alteration instructions of the propeller manufacturer are considered minor propeller alterations.

66. The engine instruments that are required on a certificated aircraft are as follows: an air-speed indicator, an altimeter, a tachometer for each engine, an oil pressure gauge for each engine when an oil pressure system is employed, a coolant thermometer for each liquid-cooled engine, an oil-in thermometer for each air-cooled engine, a manifold pressure gauge, if the engine is supercharged, a fuel quantity gauge.

67. The requirements to be met before carrying passengers for hire in an aircraft that has been seriously damaged are as follows: First, the mechanic must submit to the Civil Air Authority a set of drawings together with a stress analysis of the parts to be replaced. These must be approved, after which the mechanic may proceed with the repairs. A statement must be furnished showing that the work has been completed according to the specifications. Before passengers may be carried the aircraft must be rerated and test flown.

68. Repairs or minor alterations on a certificated aircraft may be made by a licensed engine or aircraft mechanic, a certified repair station holding the appropriate rating, the manufacturer of the aircraft, or a person under the direct supervision of a certificated mechanic holding an aircraft mechanic's rating.

69. No. A mechanic's certificate is nontransferable.

70. A certificated aircraft must be inspected every 7 days or after 25 hr. of flying time, when a line inspection is made.

After 100 hr. of flying time, a periodic inspection must be made.

71. Major repairs or major alterations on an aircraft propeller can be made only by the following: a certificated repair station holding the appropriate rating and the manufacturer of the propeller.

72. The lights that must be carried on an airplane carrying passengers for hire at night are as follows: a set of certificated standard forward-position lights in combination with the certificated taillight; also, two electric landing lights on aircraft over 1,500 lb. Only one landing light is required on aircraft weighing less than 1,500 lb.

73. Yes, if he is under the direct supervision of a certificated mechanic holding an aircraft mechanic's rating.

74. Yes, when an aircraft or an aircraft engine or propeller thereof has undergone a maintenance minor-repair, or minor-alteration operation which may have changed its flight characteristics appreciably or substantially affected its operation in flight, such aircraft shall, prior to carrying passengers, be test flown by a pilot having at least 200 solo hours and holding at least a private pilot certificate and appropriate rating for the aircraft to be test flown.

75. Yes. Safety belts are required on all certificated aircraft.

76. Yes. A line inspection—but not a periodic inspection—may be shown under the signature of a private or a commercial pilot.

77. An adequate description of every minor repair or minor alteration of an aircraft, an aircraft engine, or a propeller shall be entered in the appropriate logbook over the signature and certificate number of the mechanic directly in charge of or performing such repair or alterations. In case a manufacturer or a certificated repair station makes said repair or alteration, the appropriate logbook shall also be signed by an authorized official of the agency. The installation of an

instrument in an aircraft shall be recorded in the aircraft logbook by the agency making the installation.

78. The aeronautical knowledge of an applicant for a mechanic's certificate shall be theoretical and practical knowledge of aircraft power plants, propellers, and their appliances. It shall include knowledge how properly to inspect, maintain, and repair the same; general familiarity with the provisions of Parts 04, 13, and 14; and thorough familiarity with the provisions of Part 01, dealing with aircraft airworthiness, and the provisions of Parts 18 and 24.

79. Wooden propellers should be inspected for such defects as cracks, bruises, scars, warp, oversize holes in the hub, evidence of glue failure and separated laminations, sections broken off, and defects in the finish. The tipping should be inspected for such defects as looseness or slipping, separation of soldered joints, loose screws, loose rivets, breaks, cracks, eroded sections, and corrosion.

80. The following are the defects that would cause wooden propellers to be rejected: a crack or a deep cut across the grain of the wood; a comparatively long, wide, or deep cut parallel to the grain of the wood; a separated lamination; an excessive number of screw or rivet holes; an oversize hub or bolthole, or an elongated bolthole (the plugging and reboring of boltholes is not permissible); an appreciable warp; an appreciable portion of wood missing; a crack, cut, or damage to the metal shank of an adjustable pitch wood blade.

81. Dents, cuts, scars, scratches, nicks, etc., should be removed or otherwise treated as explained below, provided that their removal or treatment will not materially weaken the blade, materially reduce its weight, or materially impair its performance. The metal around longitudinal surface cracks, narrow cuts, and shallow scratches should be removed, to form shallow saucer-shaped depressions. Blades requiring the removal of metal forming a finished depression more than ⅛ in. in depth at its deepest point, ⅜ in. in width over all,

and 1 in. in length over all should be rendered unserviceable or a notice of rejection should be supplied to the nearest inspector of the Civil Aeronautics Administration.

82. Repair agencies are agencies that repair or alter an aircraft, or an aircraft engine, propeller, or appliance.

83. After 100 hr. of flying time, a periodic inspection is made. Some of the things that must be done on this check are to check the compression of each cylinder, to check cylinder hold-down nuts, to check tappet retaining nuts, to check the engine breather screen for cleanliness, to drain the oil system and refill, to replace spark plugs with new or reconditioned plugs, to remove the magneto breaker cover and clean and inspect the breaker compartment, to inspect the breaker points, to check all electrical connections and open all junction boxes. If the ship is equipped with an electric propeller, the speed reducer must be lubricated and the generator brushes and wiring must be inspected.

84. Only an engine and airplane mechanic may make a periodic inspection.

85. The applicant must have had at least 1 year of practical experience, or what is deemed by the administrator to be its equivalent, in the construction, inspection, maintenance, or repair of aircraft engines, propellers, and their appliances.

86. It must be placarded and must state the maximum allowable weight of contents.

87. Two separate links of wire should be used. One length of wire is to be run through the holes in the barrel of the turnbuckle and the ends of the wire are to be bent toward opposite ends of the turnbuckle. The second length of wire is then to be passed through the hole in the barrel and the ends are to be bent along the barrel on the opposite sides from the first length. The wires at one end of the turnbuckle are passed through the eye in opposite directions and one wire is laid along the barrel, while the other wire is wrapped at least four turns around the shank of the turnbuckle and the wire alongside the barrel before the end is cut off. The remaining length

of safety wire should then be wrapped at least four turns around the shank of the turnbuckle and cut off. The same wrapping procedure is repeated with the wire ends at the opposite end of the turnbuckle.

88. Yes. No person shall serve as a mechanic in conjunction with the inspection, maintenance, overhaul, or repair of air craft, aircraft engines, propellers, or appliances thereof, or as a parachute rigger, after June 15, 1942, unless he has in his possession, in addition to the currently effective mechanic's certificate, an identification card, satisfactory to the administrator, containing his fingerprints, his picture, and his signature.

89. The recommendations set forth in the manufacturer's manuals, except when in conflict with the Civil Air Regulations.

90. A certificated mechanic means a mechanic certificated in accordance with the provisions of the Civil Air Regulations (CAR 24).

91. Yes. A certificated mechanic may work on an uncertificated aircraft.

92. No one but the manufacturer may repair either a hollow or a solid steel propeller.

93. The line inspection may be made by a private pilot, a commercial pilot, and an airplane engine mechanic.

94. Crankshafts should be carefully inspected for alignment. Crankshafts that have been in aircraft that have nosed over and are bent beyond the manufacturer's permissible alignment limits should not be repaired but must be replaced.

95. No. Cotter pins and safety wire should not be used over.

96. After an aircraft engine has been overhauled, it should be run in in accordance with the pertinent aircraft engine manufacturer's instructions. If no special test stand, test club, and equipment are available, the plane should be headed into the wind during the run-in on the ground so that the maximum cooling effect will be obtained. Proper cooling during the run-in cannot be overemphasized. The manu-

facturer's recommendations concerning permissible head, barrel, and oil temperatures should be carefully observed.

97. The safety equipment required on certificated aircraft carrying passengers for hire includes a first-aid kit, certificated safety belts for all passengers and members of the crew, a hand fire extinguisher, a set of spare fuses, and landing flares.

98. The aircraft logbook should show reports of all line and periodic inspections, flight time and time on the aircraft, any structural change, any rigging change in the aircraft, damage if any, repairs and alterations of the aircraft structure and of the propeller. The engine log should show current reports of the line and periodic inspections, duration of the running time of the engine, any changes in engine installation and of the overhaul and alteration of the engine, and any damage to the engine.

99. The equipment necessary for making over-water hops included an approved life preserver or flotation device for each person for whom there is a seat, a white anchor light and a Very pistol, certified landing flares, and a set of spare fuses.

100. The minimum tip clearance required on a propeller of a landplane is 9 in.; on a seaplane, 18 in.

CHAPTER II

POWER PLANTS IN GENERAL

Of all the means of developing power, the four-stroke cycle internal-combustion engine is the most practical at the present time. The modern power plant is a highly specialized mechanism that requires knowledge and skill on the part of the operator.

Internal-combustion engines are a class of prime movers known as *heat engines*. They convert fuel into power through a process of definite events. These events are known as a *cycle* when completed in the proper order. The four-stroke cycle engine utilizes four strokes of the piston to complete the cycle, hence its name.

It is not correct to call an engine a motor. A motor is a mechanical or an electrical device to convert one form of energy into another, whereas the essential difference between a motor and an engine is that the engine converts fuel into power. The heat energy of the fuel is converted to mechanical energy. Energy may be expressed as the ability to do work.

Work is the overcoming of resistance through a distance. The unit of work is the foot-pound. A foot-pound is the equivalent of raising one pound one foot. Horsepower is the rate of doing work.[1] One horsepower is 550 ft.-lb. in 1 sec., or 33,000 ft.-lb. in 1 min. Horsepower must always be associated with time to determine the quantity of work. Heat is a form of energy, energy is the power to do work, therefore, heat is convertible to mechanical work. A British thermal unit (B.t.u.) is used for expressing the quantity of heat. One B.t.u. is equivalent to 778 ft.-lb. of work. This is known as the *mechanical equivalent* of heat.

The six principal operations in the cycle are

1. Admission of the charge to the cylinder.
2. Compression of the charge.
3. Ignition.
4. Combustion.
5. Expansion of the combustion products.
6. Exhausting or scavenging of the burnt charge.

The average pressure developed on the piston head by the expansion of the burning gases within the cylinder is known as the *mean effective pressure,* m.e.p. It follows, that if we can raise the m.e.p. for a given engine the horsepower will be increased. However, the power developed is dependent on the fuel used. As fuels are developed the engine can be designed to extract more energy from the fuel, and the horsepower will be greater. The limiting factor is the fuel itself. Therefore, the fuel must be developed before the engine.

Present fuels have undesirable characteristics, such as the inability to withstand extremes of temperature and pressure, resulting in detonation.

Fuel and air are fed to the cylinders in a vaporized, properly proportioned state. The more fuel-and-air mixture admitted, the more heat will be developed, resulting in a higher m.e.p. and therefore the engine will develop more horsepower. The fuel being the unstable factor, under extremes of pressure and temperature, the amount of compression is limited by the detonation or knocking qualities of the fuel used.

Airplane engines burn tremendous quantities of air to consume the fuel. It follows that the power developed by an engine is directly proportional to its air consumption. The volume of exhaust gases is another indication of power developed. The greater the volume of exhaust gases expelled, the greater is the horsepower delivered to the propeller.

To increase the horsepower of a given engine, the easiest way is to increase its speed r.p.m. The increase in power results from the greater number of power strokes per minute.

The limiting factors being critical vibration and restriction of the valves and intake system to the charge.

The inside diameter of a cylinder is called a *bore.* The piston movement between its top and bottom centers is called the *stroke.* The volume displaced by the piston in its stroke is called *displacement.* This is given in cubic inches.

Displacement is the sum of the area of the piston times the length of the stroke. Most engines are called *square engines,* that is, the bore and the stroke are approximately the same.

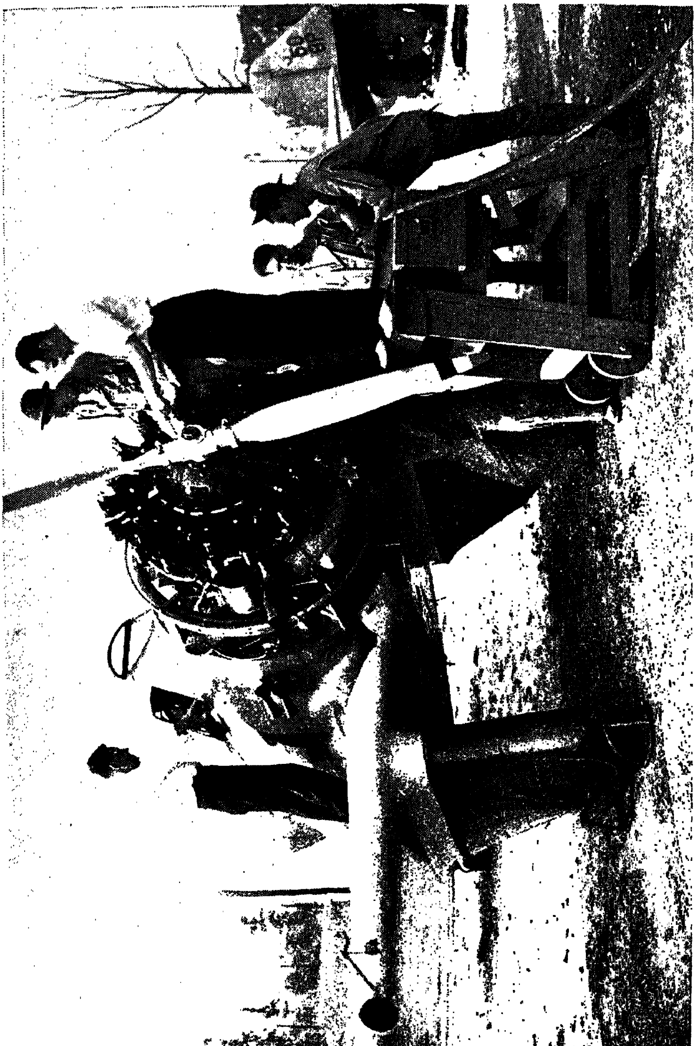
The combustion chamber is that space left in the cylinder when the piston is at top dead center. This is also called the *clearance volume.* The total volume of the cylinder is displacement volume plus clearance volume. The ratio between the swept or displacement volume and the clearance volume is expressed as a percentage. This is known as the *compression ratio.* Dividing the total volume by the clearance volume will give the compression ratio. Most engines run from 5 to 1 to 8 to 1.

The initial pressure is the density of the charge at the beginning of the compression stroke. The higher the initial pressure, the higher the compression pressure, resulting, within limits, in higher power output.

The volumetric efficiency of an engine is the amount of charge actually admitted to the cylinder as compared with the piston displacement. This also may be expressed as a percentage.

On unsupercharged engines this is always less than the piston displacement. A supercharger increases the volumetric efficiency by forcing the charge into the cylinders at pressures above atmospheric. Atmospheric pressure is 14.7 at sea level. This equals 29.92 in. of mercury.

The manifold pressure is taken as the index of the initial pressure in the cylinder. Manifold pressure when the engine is running can be either above or below atmospheric pressure, depending on the speed of the engine and on whether a supercharger is employed. Manifold pressure is the absolute pres-



Mechanics in training for the Army Air Forces, Technical Training Command.

sure of the charge in the intake manifold of the engine. The manifold pressure gauge is essentially a barometer and can be checked for proper operation against any accurate barometer. Mercury weighs 0.49 lb. per cu. in. To convert inches of mercury into pounds per square inch, multiply inches of mercury (Hg) by 0.49. 29.92 times 0.49 equals 14.7, standard atmospheric pressure at sea level.

The limiting factor in the operation of a highly supercharged engine is the fuel itself.

The index to the initial pressure and resulting m.e.p. is the manifold pressure. The manufacturer states the limits of manifold pressure. This should not be exceeded by the operator.

The actual efficiency of an engine is the amount of power developed compared to the amount of energy furnished by the heat as extracted from the fuel. This is known as the *thermal efficiency* of an engine. This heat efficiency is rather low, as a large amount of heat must be dissipated by the engine to prevent serious damage. The cooling and oil systems, conduction, radiation, and losses through the exhaust rid the engine of the excess heat. Friction and pumping losses also take their toll, the result being that about 34 per cent of the heat energy of the fuel is available for power at the present time.

Metallurgy will contribute to the development of the airplane engine. To concentrate large horsepower in a small package calls for the finest of metals, to withstand the stresses and temperatures developed by the engine. High-stress concentration will result in fatigue of the metal. This is a problem for the designer.

COMPONENT PARTS

The following descriptive material is not intended to replace a textbook, but to review the subject matter as briefly as possible.

The basic parts of an engine are piston, cylinder, crankshaft, and crankcase.

Piston.—The piston is the first part to receive the pressure derived from the expansion of the burning gases within the cylinder. It transmits this pressure through a connecting rod to the crankshaft. The crankshaft changes the linear motion of the piston to rotary motion.

The piston is made of aluminum-alloy forgings. It is a light material and has excellent heat-conducting properties, which is highly desirable. The top part of the piston is called the *head,* the lower part the *skirt.* Protruding portions within the piston are called the *bosses.* These receive the *wrist pin* (piston pin). The head of the piston may be of different shapes to aid in turbulence of the charge. The ring grooves are machined to receive the piston rings. The side portions of the grooves are called the *ring lands.* The underside of the piston head is often ribbed to aid in cooling and to strengthen the piston.

The wrist pins are made of high-grade steel, are tubular for lightness, and generally are free to float in both piston and connecting rod. This construction is known as *full floating.* Coiled springs, snap rings, and aluminum plugs are some of the devices to prevent the piston pin from scoring the cylinder walls.

Piston rings are to seal the cylinder. Their function is to hold the compression in the cylinder and to prevent excess oil from entering the combustion chamber. They are generally made of high-quality cast iron and are machined to very small tolerances. These tolerances are given in micro-inches. One micro-inch corresponds to one millionth of an inch. They must always be installed in the manner prescribed by the manufacturer.

Cylinder.—Cylinders are enclosed chambers and are made of forged-steel barrels, with cast or forged heads. Most engines have composite cylinders, that is, forged-steel barrels and aluminum-alloy heads. The barrels are screwed and shrunk into the heads and are generally not removable. Valve guides and seats, spark-plug bushings, rocker-arm bushings are shrunk into the cylinder heads.

Some engines have a choke-bore cylinder. This means that the head of the barrel is of smaller diameter than the bottom. As the cylinder expands because of the heat, the greater expansion at the top results in an almost straight bore.

To reduce wear, the cylinders of modern engines are nitrided or porous chrome plated. This leaves an extremely hard wearing surface. Cylinder grinding, or rather regrinding, is generally not recommended, as this wearing film may be penetrated through to the softer cylinder metal.

Connecting Rods.—Connecting rods transmit the power developed on the piston head to the crankshaft. They are made of chrome-nickel steel (CNS). Because of the high stresses involved, their construction calls for extreme accuracy, careful machining, and polishing. In highly stressed parts, such as the connecting rod, particular care is taken to remove all toolmarks. A slight surface scratch could set up initial fatigue of the metal and result in ultimate failure of the part.

Connecting rods are of three types—plain, fork-end blade, and articulating. Plain rods are used in small opposed-type engines. The fork-end blade is employed in V-type engines and consists of two rods operating on each crankpin. The articulating type of rod is used in radial engines and some V-type engines. It consists of a master rod and one or more link rods attached to the master rod through the medium of a link pin (knuckle pin). The type of engine construction governs the selection of the connecting rod.

Crankshaft.—Crankshafts change the linear motion of the piston into rotary motion and deliver power to the propeller. They are generally of hollow construction for lightness, also to provide chambers for the lubricating oil under pressure. They are statically and dynamically balanced and incorporate counterbalances of either the fixed or the dynamic type. The purpose of the counterbalances is to absorb torsional vibration. Radial engines use short, stubby crankshafts that are able to withstand severe stresses. In-line engines, using a rather lengthy crankshaft, limit the number of cylinders to

six in a row, to minimize torsional stress. When more power is required, other rows or banks of cylinders are added, resulting in a V, W, or X type of engine.

Crankshafts are generally of three types—360, 180, or 120 deg. The crankshaft consists of main bearings or journal, crank arm or cheek, and crankpin. They are generally made of chrome-nickel steel. On large engines the power is delivered from the crankshaft to the propeller through suitable reduction gearing. The purpose of reduction gears is to permit the engine to attain maximum power (more power strokes per minute) and at the same time to permit the propeller to attain maximum efficiency. In all instances the propeller speeds will be less than crankshaft speeds. The average ratios will run between 2 to 1 to 8 to 5. The first figure designates engine r.p.m. and the second, the propeller speed.

Crankcase.—The crankcase is the foundation of the engine. It also serves to transmit the thrust from the propeller to the airplane structure. It is generally of aluminum-alloy construction, carefully machined to receive the crankshaft and accessory drives. The main crankcase section on some late-model radial engines is of forged steel the better to withstand the greater pressures of higher output engines.

Valves.—The function of valves is to open and close ports in the cylinders to allow the charge to enter and the burnt gases to be expelled. The poppet valve is conventional in this country. However, the sleeve-type valve has proved successful abroad. Valves are constructed of tungsten or silchrome steel. These metals are called *austenitic*, that is, they retain their strength at high temperatures. Most valves have a layer of stellite fused to face and tip. This resists burning, pitting, warping, corrosion, and wear. This type of valve is usually ground at an angle of ½ deg. less than its seat. Better operating characteristics and longer life result from the so-called "line contacts."

Some engines incorporate sodium-filled valve heads and stems; the function being the rapid transfer of heat from the

valve head. The valve seat and the valve guide provide the principal means of cooling the valves and, on modern engines, the overhead oiling system assists in this function. Valves are opened by cams and closed by coil springs. Most engines use multiple-coil springs. The function of two or more springs is to minimize valve-spring surging, also to increase the safety factor. Valve springs must always be checked for general condition and tension at overhaul periods.

In-line engines use camshafts, while radial engines use cam plates. The shafts or plates incorporate lobes. These lobes operate the valves through suitable push rods, rocker arms, etc. Valve speed on all four-cycle engines is one-half crankshaft speed.

Valves are timed during the assembly of the engine. The so-called "valve timing" is the procedure for checking the timing to ensure that the engine was assembled correctly.

Valve-timing specifications are given in respect to crankshaft position. They refer to the number of degrees before and after top center and bottom center of the piston. The piston position is governed by the crankpin position; therefore, a given number of degrees is equivalent to saying that the piston is 1⅜ in. before top center, etc.

TC is the abbreviation for top center; BC, for bottom center; ATC, for after top center; BTC, for before top center; ABC, for after bottom center; BBC, for before bottom center. These symbols are used in valve and ignition timing. On radial engines a formula for deriving cam speeds is cam speed equals one half crankshaft speed, divided by the number of lobes on either cam track. Timing disks, in conjunction with top center indicators, or reduction-gear markings are some of the common means employed in checking valve timing.

Bearings.—The function of bearings is to reduce metallic friction to a minimum. They are of three general types—plain, ball, and roller. A subdivision of the roller type is the needle bearing. The table represents briefly the characteristics of each type of bearing.

CHARACTERISTICS OF BEARINGS

Plain	Roller	Ball
Greatest loads	Less loads	Least loads
Most friction	Less friction	Least friction
Generates most heat	Less heat	Least heat
Requires most lubrication	Less lubrication	Least lubrication

The modern bearing represents years of engineering and research. Manufacturers' specifications should always be followed. Superchargers, intake and exhaust systems, carburetion, ignition, propellers, instruments, and various other accessories are covered in their respective paragraphs. The importance of these contributing factors to engine operation warrants detailed descriptions of their individual functions.

The modern engine is a highly specialized mechanism, and requires a thorough knowledge and study on the part of the maintenance mechanic and operator. In the past 15 years, horsepower per cubic inch of displacement has increased 85 per cent, while the displacement has actually decreased 15 per cent. The factors responsible for this improvement in efficiency have been better fuels, higher mean effective pressures, higher r.p.m., and improved materials. These improvements necessarily call for improved maintenance technique. Further developments are foreseen in the immediate future.

MULTIPLE-CHOICE QUESTIONS*

1. True TDC of the piston for valve timing is when
a. the piston is at the very top, regardless of the crankshaft
b. the piston pin, crankpin, and crankshaft are in a straight line
c. a point is indicated by the TC indicator
d. the point is at TC on the timing disk

2. The magneto should be timed
a. on the intake stroke

* A key to the answers is given on p. 67.

b. with the breaker points fully opened
c. on the compression stroke
d. with the breaker points retarded

3. Clearance between the valve stem and rocker arm on a radial engine is to
a. compensate for valve's expansion
b. ensure correct timing
c. ensure the valve closing
d. provide the proper valve overlap

4. What is meant by fixed ignition?
a. the magneto has been timed to the engine
b. no spark control is employed
c. a magneto and distributor built into one unit
d. a recently repaired magneto

5. In order to set the valve clearance for timing, turn the
a. crankshaft one-quarter turn after the intake opens
b. crankshaft one-quarter turn after the exhaust closes
c. crankshaft one-quarter after the intake closes
d. piston to TDC of compression stroke

6. If the valve clearance were set too close, the valve would
a. open early and close late
b. open late and close early
c. open early and close early
d. stay open too short a period of time

7. What is meant by synchronized ignition?
a. when a single magneto is used
b. when each of the two sparks occur at the same time
c. when the magneto and distributor have been timed
d. when the spark plugs are exactly opposite each other

8. What is meant by fixed valve timing?
a. an engine that does not have to be timed
b. when the engine is timed during assembly
c. it is an expression used to denote that the engine has been timed
d. timing an engine with a timing fixture

9. The aircraft engine is called a *heat engine* because it
a. gets hot
b. converts heat energy into mechanical energy
c. takes heat to vaporize the gasoline
d. burns a fuel within the cylinder

10. In the two-stroke cycle principle, it requires
a. one revolution to complete the cycle
b. two revolutions to complete the cycle
c. an engine of two cylinders
d. two pistons connected on one connecting rod

11. When in the cycle are both valves closed?
a. at the end of intake and beginning of exhaust
b. at the end of exhaust and beginning of intake
c. during expansion and compression
d. during intake and exhaust

12. In what position are magnetos timed?
a. in the advanced position
b. in the retarded position
c. at TC
d. just past TC

13. To increase the compression pressures of the mixture in an engine
a. decrease the piston displacement
b. increase the size of the combustion-chamber space
c. increase the speed of the supercharger
d. use a fuel with a high octane rating

14. The cylinder volume is
a. distance from top of combustion chamber to piston (piston on bottom center)
b. piston displacement added to the combustion-chamber space
c. the combustion-chamber space plus length of stroke
d. the compression ratio times the number of cylinders

15. An engine is said to be supercharged when the
a. piston displacement is greater then 100 cu. in.
b. compression ratio is above 6 to 1

c. volumetric efficiency is over 100 per cent
d. thermoefficiency is over 100 per cent
16. Cubic inches per horsepower rating of an engine is found by dividing the
a. horsepower by the piston displacement of the cylinder
b. horsepower by the piston displacement of the engine
c. piston displacement of a cylinder by the horsepower
d. piston displacement of the engine by the horsepower
17. The power delivered at the propeller is known as
a. indicated horsepower
b. friction horsepower
c. brake horsepower
d. weight per horsepower
18. The mechanical efficiency of an engine is
a. b. hp. divided by i. hp.
b. i. hp. divided by b. hp.
c. i. hp. divided by friction horsepower
d. i. hp. minus b. hp.
19. In an internal-combustion engine the power is developed by
a. the expansion of the burning gases in the cylinder
b. octane rating of the fuel used
c. the mixture delivered by the supercharger
d. explosion of the gasoline mixture
20. The Diesel engine operates on
a. the two-stroke cycle principle only
b. the four-stroke cycle principle only
c. either the two- or the four-stroke cycle principle
d. an entirely different cycle principle
21. Valve overlap occurs on a 14-cylinder engine
a. at the end of the power stroke
b. at the beginning of compression stroke
c. when the piston is at TC with both valves closed
d. at the beginning of the intake stroke
22. Nonvariable or fixed ignition timing is used on aircraft engines because

a. of danger of operating in the retarded position
b. of danger of operating in the advanced position
c. it does not have to be adjusted
d. it develops greater power

23. To increase the compression ratio, you would
a. increase combustion-chamber space
b. install a blower
c. install a carburetor heater
d. install a high-dome piston

24. Piston displacement is
a. volume of cylinder less combustion-chamber space
b. area of piston head less combustion-chamber space
c. circumference of piston times length of stroke
d. a ratio for computing horsepower

25. What would you do to increase the volumetric efficiency of an engine?
a. change the spark plugs
b. richen the mixture
c. increase the compression ratio
d. install a supercharger

26. What is meant by the term *weight per horsepower?*
a. the weight of 1 hp.
b. horsepower divided by engine weight
c. engine weight divided by its horsepower
d. the energy required to raise 33,000 lb.

27. Brake horsepower is determined by
a. a dynamometer
b. compression ratio
c. r.p.m.
d. indicator card

28. The purpose of a counterweight on a crankshaft is to
a. counteract torsional vibration
b. aid the inertia of the shaft
c. splash oil to the cylinder walls
d. counterbalance the weight of the piston

29. What is the thermoefficiency of an aircraft engine?

a. 6 per cent

b. 35 per cent

c. 66⅔ per cent

d. 94 per cent

30. A single-row radial engine has an odd number of cylinders to

a. give evenly spaced firing impulses

b. give more firing impulses

c. fire all cylinders in two revolutions of the crankshaft

d. use a single-throw crankshaft

31. When a cooling system is drained and flushed, what is done with the drained-off coolant?

a. it is boiled to remove impurities

b. it is strained and returns to system

c. it is saved and returned to depot for reclamation

d. it is disposed of

32. The Cuno oil filter is given one turn on what inspection?

a. daily

b. 10 hr.

c. 25 hr.

d. 50 hr.

33. The cylinder volume is

a. distance from top of combustion chamber to the piston when the piston is on BC

b. the piston displacement added to the combustion-chamber space

c. the combustion-chamber space plus the length of the stroke

d. the compression ratio times the number of cylinders

34. A 180-deg. two-throw crankshaft will be found on

a. a 9-cylinder radial engine

b. a 14-cylinder radial engine

c. a V 12-cylinder engine

d. an opposed-type 12-cylinder engine

35. A radial engine is one that has its cylinders in
a. a single circle
b. a single row
c. two banks at an angle of less than 90 deg.
d. two banks at an angle of 180 deg.

36. How many degrees of engine travel between power strokes on a 9-cylinder radial?
a. 40 deg.
b. 80 deg.
c. 90 deg.
d. 180 deg.

37. The I type of cylinder is generally employed on aircraft engines because of
a. simple valve mechanism
b. higher power output
c. compactness
d. less resistance to the air flow in flight

38. Some exhaust valves are hollow and filled with metallic sodium
a. to make them lighter
b. to help them keep cool
c. to keep them from surging
d. to make them close more rapidly

39. Two reasons for replacing valve springs are that they are
a. broken and have increased tension
b. broken and too hard
c. broken and show loss of tension
d. broken and are closing valves too soon

40. How are push rods identified?
a. the intakes are smaller
b. they are marked for the intake and exhaust valves
c. they are marked for the cylinder and for intake and exhaust valves
d. they are marked for the rocker arm and cam followers that they fit

41. The main purpose of a piston ring in an aircraft engine is to

a. keep the piston straight in the cylinder
b. provide a seal between the piston and the cylinder
c. provide a bearing surface for the piston to ride on
d. allow for expansion of the piston

42. The type of thrust bearing usually used on aircraft engines is:

a. ball bearing
b. roller bearing
c. plain bearing
d. self-aligning ball bearing

43. What is the purpose of the hot-oil or coolant jacket on intake manifolds?

a. it is an aid to vaporization
b. it prevents formation of ice
c. it heats the charge to increase volumetric efficiency
d. it preheats the charge to make combustion easier

44. What is one disadvantage of short exhaust stacks?

a. the engine will operate too cold
b. the exhaust valves will warp more easily
c. the exhaust gases dilute incoming air
d. they obstruct the pilot's vision

45. The hydraulic pump is of what type?

a. centrifugal type
b. vane type
c. gear type
d. piston type

46. How will ignition timing affect volumetric efficiency?

a. it will not affect it
b. it changes the piston displacement
c. it alters the compression ratio
d. it changes the volume of charge

47. The breaker-point clearance on magnetos with pivotless-type breaker points is

a. 1.8″

b. 0.002″
c. 0.012″
d. no set clearance

48. For what reason are the magnetos not synchronized on some types of engines?
a. longer stroke of the link rod
b. one spark plug placed closer to the exhaust valve
c. higher compression ratios
d. higher operating temperatures

49. If, upon installing a replacement oil pump, you found that the gauge pressure was too high, you would
a. get another pump
b. increase the clearance of the gears
c. adjust the pressure relief valve
d. use lighter oil in the engine

50. Why has it become necessary to increase the fin area on engines of the later types?
a. to make the engine heavier
b. to dissipate increased combustion temperature
c. to relieve the necessity of installing pressure baffles
d. to make it possible to burn lower-grade fuels

51. A blower or supercharger ratio of 7 to 1 means that the
a. blower operates through seven gears
b. blower operates seven times as fast as the engine
c. engine operates seven times as fast as the blower
d. supercharger will raise atmosphere pressure seven times

52. What two purposes do intake manifolds serve?
a. they allow for expansion and contraction and conduct the charge to the cylinder
b. they conduct the charge to the cylinder and provide space for vaporization
c. they provide a space for the fuel to vaporize and prevent backfire
d. they permit of easy removal of the carburetor and conduct the charge to cylinders

53. What is one advantage of short exhaust stacks?
a. to permit the mounting of machine guns
b. to give the pilot better vision
c. to heat an incoming charge
d. to prevent exhaust back pressure

54. The cooling pump is of what type?
a. centrifugal type
b. vane type
c. gear type
d. piston type

55. How will valve timing affect volumetric efficiency?
a. it will not affect it
b. it changes the piston displacement
c. it alters the compression ratio
d. it changes the volume of the charge

56. What is the purpose of twin ignition?
a. to increase the rate of combustion
b. to burn the charge quickly
c. to complete combustion
d. to give a hotter spark

57. If a new gear-type scavenger pump will not pump oil out of the sump
a. the oil tank is too full of oil to allow it to return
b. there is a leak in the pump scavenger line
c. the gears are meshed too close
d. the pressure-relief valve is set too low

58. Upon examining a cylinder of a late type you would find
a. approximately the same fin area on both exhaust- and intake-valve chambers
b. more fins on the exhaust-valve chamber
c. more fins on the intake-valve chamber
d. same number of fins on each side

59. One pre-flight inspection on the cooling system of a liquid-cooled engine is to
a. drain and flush the cooling system
b. check the coolant supply

c. check around cylinder banks for leaks
d. check band markings on coolant lines

60. What kind of material is used on the induction-pipe packing gland?

a. cork
b. rubber
c. lead-graphite packing
d. asbestos

61. The oil pump is of what type?

a. centrifugal type
b. vane type
c. gear type
d. piston type

62. Select the correct arrangement of the sections of the crankcase of a four-section radial engine.

a. front section, supercharger section, accessory section, power section
b. cam-plate section, blower section, main section, rear section
c. nose section, power section, mounting section, accessory section
d. nose section, supercharger section, crankshaft section, pump section

63. A diffuser plate is used to

a. force the charge of fuel and air into the cylinder
b. change the high velocity of the charge to pressure
c. speed up the velocity of the charge
d. increase the manifold pressure

64. What is a ramming type of air intake?

a. a carburetor intake that faces into the slip stream
b. an air-intake scoop that supplies air to the radiators
c. a method of cooling high-powered air-cooled engines
d. the air intake to the cabin or cockpit

65. On what section of the radial engine are most of the accessories mounted?

a. power section
b. rear section

c. mounting section
d. supercharger section

66. What is the purpose of the packing glands on the induction pipes?
a. to prevent vibration
b. to make installation easier
c. to allow for expansion
d. to provide a place to blow out in case of backfire

67. Compression ratio is found by piston displacement
a. divided by combustion chamber
b. times combustion chamber divided by combustion chamber
c. plus combustion chamber divided by combustion chamber
d. plus length of stroke divided by combustion chamber

68. Which is the correct order of events to complete a cycle?
a. ignition, combustion, power, compression, exhaust
b. intake, ignition, compression, power, exhaust
c. intake, compression, ignition, power, exhaust
d. intake, combustion, power, ignition, exhaust

69. What is the importance of ignition timing?
a. to burn the charge
b. to have the charge completely burned at top center
c. to ignite the charge at top dead center
d. to burn the charge as the piston goes down

70. During the compression strokes
a. both valves are open
b. both valves are closed
c. the intake valve is open
d. the exhaust valve is open

71. Supercharging increases the
a. piston displacement
b. compression ratio
c. volumetric efficiency
d. thermoefficiency

72. What is the purpose of an oil pressure relief valve?
a. prevents overloading of the pump
b. permits oil to by-pass the screen if the screen plugs up
c. prevents damaging the screen if the screen plugs up
d. maintains a constant oil pressure on the bearings

73. In what section of a radial engine are the journal bearings located?
a. in the accessory section
b. in the supercharger section
c. in the nose section
d. in the main or power section

74. The purpose of the crankshaft breather is to
a. prevent pressure in crankcase
b. allow excess oil to escape in flight
c. allow atmospheric pressure to return oil to the scavenger pump
d. bleed air into the induction system

75. Piston displacement is found by
a. area of piston plus length of stroke
b. area of piston times length of stroke
c. diameter of piston times length of stroke
d. one-half the diameter times length of stroke

76. Volumetric efficiency is found by
a. volume of charge admitted divided by piston displacement
b. volume of charge admitted divided by combustion chamber
c. piston displacement divided by volume of charge
d. piston displacement plus volume of charge divided by volume of charge

77. At what position does ignition occur?
a. BTC
b. at TC
c. a little past TC
d. a little past BC

78. During the expansion or power stroke
a. both valves are open
b. both valves are closed
c. the intake valve is open
d. the exhaust valve is open

79. To increase the horsepower of a given engine you would
a. increase the fuel pressure
b. install a supercharger
c. increase the size of the combustion chamber
d. use higher octane fuel

80. What is the advantage of the back-pressure oil pressure relief valve?
a. only the oil used in the engine is screened
b. it permits the engine to receive oil if the screen plugs up
c. it requires less pressure
d. it supplies higher pressure

81. On what section of the radial engine would you find the diffuser plate?
a. on the main section
b. on the front section
c. on the accessory section
d. on the supercharger section

82. The fuel pump is of what type?
a. centrifuge type
b. vane type
c. gear type
d. piston type

83. What is a remote engine-driven gearbox used for?
a. to supply the power to operate machine guns
b. to reduce the propeller speed
c. to operate engine accessories
d. to operate a controllable pitch propeller

84. The cylinders on a V-type engine are numbered
a. clockwise from the antipropeller end
b. counterclockwise from the antipropeller end

c. from the antipropeller end
d. from the propeller end

85. An opposed-type engine is one that has its cylinders in
a. a single circle
b. two circles
c. two banks at an angle less than 90 deg.
d. two banks at an angle of 180 deg.

86. Why are the cylinders staggered on the double-row radial engine?
a. so as not to have two power strokes at the same time
b. to permit better cooling
c. because of the type of crankshaft used
d. to make service and repair easier

87. How does the V-type engine reduce the weight per horsepower?
a. by putting six cylinders in one bank
b. by permitting the use of lighter materials in its construction
c. by the use of 12 cylinders on one engine
d. by the use of a single crankshaft

88. What type of crankshaft is used on a V-type, 12-cylinder engine?
a. 120 deg.
b. 180 deg.
c. 220 deg.
d. 360 deg.

89. What is the correct firing order for a 14-cylinder radial engine?
a. 1-3-5-7-9-11-13-2-4-6-8-10-12-14 odd numbers—front row
b. 1-3-5-7-9-11-13-2-4-6-8-10-12-14 odd numbers—rear row
c. 1-10-5-14-9-4-13-8-3-12-7-2-11-6 odd numbers—front row
d. 1-10-5-14-9-4-13-8-3-12-7-2-11-6 odd numbers—rear row

90. In a geared engine, what is the purpose of the gearing?
a. to decrease the speed of the propeller
b. to use a controllable-pitch propeller

c. to increase the speed of the propeller
d. so that a fixed-pitch propeller may be used

91. What is the purpose of the crankshaft counterweight?
a. to counteract vibration
b. to act as a flywheel
c. to counteract compression
d. to balance the crankshaft

92. What type of bearing has the least friction?
a. plain bearing
b. ball bearing
c. roller bearing
d. tapered roller bearing

93. The right or left side of an engine is determined from the
a. propeller end
b. antipropeller end
c. bank containing the master rods
d. cylinder containing the master rods

94. What is the advantage of a double V-type engine over two regular V types?
a. it is more powerful
b. it is more economical to operate
c. reduced frontal area
d. less weight per horsepower

95. What type of crankshaft is used on a 14-cylinder, double-row radial engine?
a. 120 deg.
b. 180 deg.
c. 220 deg.
d. 360 deg.

96. What is the correct firing order for a V-12 engine, right-hand rotation?
a. 1L-5R-3L-6R-2L-4R-6L-2R-4L-1R-5L-3R
b. 1R-6L-5R-2L-3R-4L-6R-1L-2R-5L-4R-3L
c. 1R-5L-3R-6L-2R-4L-6R-2L-4R-1L-5R-3L
d. 1L-6R-5L-2R-3L-4R-6L-1R-2L-5R-4L-3R

97. The firing order of an engine is determined by
a. type of engine, air- or liquid-cooled, direction of rotation
b. arrangement of cylinders, type of crankshaft, master-rod location
c. number of cylinders, compression ratio, type of crankshaft
d. number of cylinders, type of engine, direction of rotation

98. What is the purpose of dynamic counterbalance?
a. to equalize firing impulses
b. to aid in compression
c. to reduce torsional vibration
d. to prevent the stalling of the engine at low speeds

99. What type of thrust bearing cannot be adjusted?
a. annular ball bearing
b. self-aligning ball bearing
c. thrust ball-type bearing
d. double-row ball bearing

100. What two precautions are observed when removing push rods?
a. have both valves open, observe markings so as to replace as found
b. have both valves closed, observe markings so as to replace as found
c. have both valves open, replace with markings toward crankshaft
d. have both valves closed, replace with markings toward rocker boxes

101. A full-floating piston pin is one that
a. turns in both the link rod and the piston
b. turns in the piston only
c. turns in the link rod only
d. is held in by a set screw

102. What type of valves is used on aircraft engines?
a. sliding valves
b. poppet valves
c. piston valves
d. sleeve valves

103. What are valve tappets?
a. this is another name for camshaft lobes
b. this is another name for cam followers
c. this is another name for valve stem guide
d. this is another name for rocker arms
104. Valve-seat inserts are
a. pressed-in guides to line up valve seats
b. shrunk-in rings for valves to seat on
c. shrunk-in rings to guide valves
d. pressed-in guides to prevent wear on valves
105. What is the purpose of multiple valve springs?
a. one spring would not be strong enough
b. two springs hold the valve closed longer
c. to allow for elongation of the valve stem
d. to prevent the valve spring's surging
106. How would you tell an intake from an exhaust valve?
a. the exhaust valve has a larger stem
b. the intake valve has a larger stem
c. the exhaust valve has a larger face
d. the intake valve has a larger face
107. One of the following formulas is the formula for indicated horsepower:

(*a*) $\dfrac{PL\ ANK}{33{,}000}$

(*b*) $\dfrac{A \times \text{m.e.p.} \times S/12 \times (\frac{1}{2}\ \text{r.p.m.}) \times N}{33{,}000}$

(*c*) $\dfrac{\text{b.hp.} \times 33{,}000}{LAE}$

(*d*) $\dfrac{\text{b.hp.} \times 33{,}000}{LAP}$

(*e*) $\dfrac{A \times \text{m.e.p.} \times S/6 \times (\frac{1}{2}\ \text{r.p.m.}) \times N}{33{,}000}$

108. Feathered edges on valves will cause
a. backfiring in the carburetor
b. loss of compression caused by leaky intake valves
c. the cylinders to miss

d. the engine to run rough
e. preignition

109. Boyle's and Charles's laws are laws pertaining to
a. the starting of engines
b. Civil Air Regulations
c. repair and alteration of aircraft
d. liquids
e. gases

110. Piston rings are made of
a. cast iron
b. cast aluminum alloy
c. die-cast aluminum alloy
d. drop-forged steel

111. The cam lobes have ramps on each side to
a. slow down the rate of closing time of the valves
b. slow down the rate of opening of the valves
c. prevent damaging the assembly by abrupt opening of valves
d. prevent wearing of the valve stems
e. create smoother operation

112. Cylinder-head temperatures are indicated by
a. detonation
b. incorporation of a thermocouple
c. condition of the plugs
d. behavior of the engine

113. The procedure for installing a bearing in a master rod of a radial engine is
a. to protect the ends of the bearings with a wooden block when hammering in
b. to allow the rod to stand in hot oil for half an hour, then press the cold bearing into it
c. to keep the master rod on its side while inserting the bearing
d. to chill the master rod with dry ice, then heat the bearing and force it in
e. to remount the master rod 0.003

114. Prolonged idling of an aircraft engine may cause

a. excessive pitting of exhaust valves
b. the oil to break down because of improper circulation
c. spark plugs to foul
d. an excessive current to be built up in the magneto secondary circuit
e. the carburetor to flood

115. To determine when a valve has been sufficiently ground, you should

a. test the seat for passage of daylight
b. measure the portion of the valve that is not in contact with the seat
c. test by the use of prussian blue
d. test under 200 lb. of air pressure or see if it will hold a fluid
e. heat the valve in boiling oil

116. When dismantling an engine prior to overhaul, you would loosen the thrust nut before removing the spark plugs, because

a. when spark plugs are in, the thrust nut is easier to turn
b. the thrust-nut wrench would not fit if the plugs were removed
c. the compression of the cylinders will help prevent the shaft from turning
d. leaving the plugs in and retaining the oil in the cylinders will assist in preventing the shaft from turning.

117. The purpose of the pressure relief valve in the lubricating system is to

a. help maintain a constant oil temperature
b. maintain a proper level of oil in the sump
c. assist in maintaining a constant manifold pressure
d. maintain a constant oil pressure

118. The most common air-cooled engine is

a. an in-line engine
b. an inverted engine
c. a radial engine
d. a horizontal engine

119. In the disassembling of an engine for a top overhaul, the last cylinder to be removed should be the

a. fourth cylinder in firing order
b. first cylinder in firing order
c. master-rod cylinder
d. last cylinder in firing order

120. After a cylinder has been removed from an engine, the next part to remove is the

a. thrust bearing
b. nose section
c. piston
d. piston rings

121. The main reason why pistons are made of a light material is to

a. reduce back pressure
b. reduce the weight of the engine
c. balance the engine
d. hold the torque to a minimum

122. The material used in air-cooled cylinder construction is

a. cast-iron head, cast-iron barrel
b. aluminum head, forged-steel barrel
c. aluminum head, cast-iron barrel
d. both head and barrel must be of the same material

123. Side clearance between the ring and the piston land is necessary to

a. ensure proper lubrication
b. assist the oil to drain from the ring
c. overcome piston friction
d. prevent the ring from sticking in the groove of the piston

124. The purpose of a piston ring is to

a. prevent the piston from contacting the cylinder wall
b. prevent leakage of pressure from the combustion chamber
c. help prevent the formation of carbon on the piston
d. prevent overheating

125. Which type of piston pin is used in most aircraft engines?

a. stationary
b. oscillating
c. solid
d. floating

126. The purpose of a crankshaft is to
a. change reciprocating motion to rotary motion
b. operate the engine
c. decrease vibration
d. develop the power of the engine

127. Crankcases are inspected for defects by
a. local etching
b. tapping with a soft mallet and inspecting with a magnifying glass
c. submerging in a combination of hot oil and small metal particles
d. magnifluxing

128. Checking the condition of piston pins and knuckle pins is done with
a. a dial indicator and V blocks
b. an inside micrometer
c. outside calipers
d. a square

129. Synchronized ignition timing means
a. both spark plugs in one cylinder spark at the same time
b. two cylinders fire at the same time to aid in power overlap
c. proper burning of the charge in the cylinder
d. assisting in the volumetric efficiency of the cylinder

130. The purpose of valve overlap is
a. to eliminate detonation
b. to retain hot exhaust gases that will preheat the incoming charge
c. to increase the volumetric efficiency
d. to allow the cylinder to operate at a higher temperature

131. Approximate cylinder-head temperatures in normal operation should be about
a. 60 to 100°C.

b. 160 to 200°C.
c. 360 to 500°C.
d. 140 to 160°C.

132. Intake manifold pressure is
a. pressure in the cylinder
b. pressure in the exhaust system
c. pressure in the induction system
d. pressure in the oil system

133. The number of sparks that a four-stroke cycle, nine-cylinder engine requires in two revolutions of crankshaft with double ignition are
a. nine
b. eighteen
c. one
d. two

134. A valve that has a poor seat will result in
a. high oil consumption
b. too-rapid formation of carbon
c. loss of compression
d. increased charge capacity

135. When an engine is operating, blue smoke from the exhaust would possibly indicate
a. worn gears in the oil pressure pump
b. too-low oil pressure
c. too-high fuel pressure
d. excessive clearance in the master-rod bearing

136. Warping of valves may be caused by
a. too much valve clearance
b. shutting off the engine too soon after operating at high speeds and temperatures
c. improper carburetor mixture
d. too-low oil pressure

137. The number of degrees between the cylinders of a nine-cylinder radial engine is
a. 38
b. 80

c. 40
d. 46
138. The formula for finding piston displacement is
a. bore × bore × stroke
b. bore × stroke
c. area of bore × stroke
d. area of bore × area of bore × stroke
139. Brake horsepower is
a. indicated horsepower plus friction horsepower
b. indicated horsepower times friction horsepower
c. indicated horsepower divided by friction horsepower
d. indicated horsepower minus friction horsepower
140. One horsepower equals
a. 33,000 ft.-lb. per sec.
b. 550 ft.-lb. per min.
c. 33,000 ft.-lb. per min.
d. 550 ft.-lb. per hr.
141. To change the manifold pressure it is necessary to
a. use the mixture control
b. use the automatic spark control
c. change the throttle setting
d. use a higher octane fuel
142. The most common cylinder-barrel trouble is
a. taper and out of round
b. loose cylinder head
c. worn or broken cooling pins
d. cracked or broken
143. If a crankcase shows a crack upon inspection, the remedy is
a. braze the crankcase
b. weld the crack
c. fill the crack with a tight seal
d. replace the unit
e. use it if it is not on the mounting section
144. Thrust bearings used in the nose section of radial engines are

a. plain
b. roller
c. shallow-grooved ball
d. deep-grooved ball

145. An advantage of liquid-cooled engines over air-cooled engines is that they are
a. easier to streamline
b. lighter per horsepower
c. less trouble with cooling problems
d. more economical

146. The advantage of air-cooled systems over liquid-cooled systems is that they are
a. lighter per horsepower
b. easier to streamline
c. easier in the control of cooling
d. operated at a more even temperature

147. Which of the following is the order of events in a four-stroke cycle engine?
a. intake, compression, ignition, power, exhaust
b. intake, compression, power, ignition, exhaust
c. intake, power, compression, ignition, exhaust
d. intake, power, compression, intake, exhaust

148. The number of foot-pounds in 1 B.t.u. is approximately
a. 878
b. 778
c. 578
d. 678

149. The weight of an aircraft engine per horsepower is approximately
a. 10 lb.
b. 5 lb.
c. $2\frac{1}{2}$ lb.
d. $1\frac{1}{2}$ lb.

150. The thermal efficiency of an aircraft engine will average
a. 50 per cent
b. 40 per cent

c. 35 per cent
d. 20 per cent

ESSAY-TYPE QUESTIONS*

151. What kind of engine is an internal-combustion engine?

152. What is the purpose of an internal-combustion engine?

153. What is meant by the term *cycle?*

154. Explain how knuckle pins are lubricated.

155. How are knuckle pins held in place on a radial engine?

156. Why is it necessary to fill exhaust valves with a sodium solution?

157. What will cause valves to warp?

158. How is a crankshaft checked for runout?

159. What two clearances must be checked when piston rings are being installed?

160. What would be the effect of a leak in the intake pipe?

161. Why are intake valves timed to open in BTC position and close in ABC position of the pistons during normal operation of high-output aircraft engines?

162. Why are exhaust valves timed to close ATC on the intake stroke during normal operation of the aircraft engine?

163. What is meant by the term *compression ratio?*

164. What is meant by the term *volumetric efficiency?*

165. What device may be used to increase the volumetric efficiency of an engine?

166. What is meant by the term *indicated horsepower?* What is the formula?

167. What is meant by the term *friction horsepower?* What is the formula?

168. What is meant by the term *brake horsepower?*

169. What is the firing order of a conventional V-type, 12-cylinder engine?

170. What feature is usually incorporated in the aircraft engine to relieve gear stresses in the impeller gearing?

* Answers are given on p. 68.

171. How are relief valves adjusted in aircraft-engine lubricating systems?

172. During disassembly of an engine, what group of parts is usually removed first?

173. State the proper method of increasing the gap clearance of a piston ring.

174. What is the purpose of the crankcase breather on an internal-combustion engine?

175. What type of oiling system is used in most aircraft engines? Name three types of oil systems.

176. Why are air deflectors or pressure baffles used in high-performance, air-cooled aircraft engines?

177. What is the disadvantage of the use of pressure baffles on an air-cooled engine?

178. What are the inspection requirements for oil drain plugs and oil cocks?

179. Are oil screens and Cuno strainers removed and cleaned after the ground test of newly installed engines?

180. What would be the effect of wrong valve clearance?

181. Explain the purposes of a piston.

182. Name three different types of piston pins.

183. What is the purpose of the connecting rod?

184. Give three methods of installing a full-floating piston pin in a piston to prevent scoring of the cylinder.

185. Give the firing order of a six-cylinder in-line engine.

186. Name the procedure for adjusting valve clearances (cold) on a conventional nine-cylinder radial engine.

187. Name two procedures for checking an exhaust valve for blow-by.

188. What is meant by a general trouble? by a local trouble? Give an example of each.

189. What is the purpose of a turbosupercharger? Explain.

190. Where does the turbosupercharger get its power?

191. What is the difference between a preheater and a hot spot?

192. Name four methods of starting an aircraft engine.

193. Why are the inside surfaces of cylinders on aircraft engines processed or nitrided?

194. Which row of cylinders has the odd numbers on a double-row radial engine?

195. Give the general procedure for checking ignition timing on most aircraft engines (radial).

196. What is meant by the terms b.hp., m.e.p., TDC, BDC, CAT, i.m.e.p.?

197. What is meant by maximum power, rated power? Explain.

198. What is detonation?

199. What are the effects of severe or prolonged detonation?

200. Which is always higher in an engine, i.hp. or b.hp.?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 40

1. *b*	2. *c*	3. *a*	4. *b*	5. *d*	6. *a*
7. *b*	8. *b*	9. *b*	10. *a*	11. *c*	12. *a*
13. *c*	14. *b*	15. *c*	16. *d*	17. *c*	18. *a*
19. *a*	20. *c*	21. *d*	22. *a*	23. *d*	24. *a*
25. *d*	26. *c*	27. *a*	28. *a*	29. *b*	30. *a*
31. *b*	32. *a*	33. *b*	34. *b*	35. *a*	36. *b*
37. *b*	38. *b*	39. *c*	40. *c*	41. *b*	42. *a*
43. *a*	44. *b*	45. *c*	46. *a*	47. *d*	48. *b*
49. *c*	50. *b*	51. *b*	52. *b*	53. *d*	54. *a*
55. *d*	56. *b*	57. *b*	58. *b*	59. *b*	60. *b*
61. *c*	62. *c*	63. *b*	64. *a*	65. *b*	66. *c*
67. *c*	68. *c*	69. *b*	70. *b*	71. *c*	72. *d*
73. *d*	74. *a*	75. *b*	76. *c*	77. *a*	78. *b*
79. *b*	80. *a*	81. *d*	82. *b*	83. *c*	84. *c*
85. *d*	86. *b*	87. *d*	88. *a*	89. *d*	90. *a*
91. *a*	92. *b*	93. *b*	94. *c*	95. *b*	96. *d*
97. *d*	98. *c*	99. *c*	100. *c*	101. *a*	102. *b*
103. *b*	104. *b*	105. *d*	106. *a*	107. *a*	108. *c*
109. *c*	110. *a*	111. *c*	112. *b*	113. *b*	114. *c*
115. *d*	116. *c*	117. *d*	118. *c*	119. *c*	120. *c*
121. *c*	122. *b*	123. *d*	124. *b*	125. *d*	126. *a*
127. *a*	128. *a*	129. *a*	130. *c*	131. *b*	132. *c*
133. *b*	134. *c*	135. *d*	136. *b*	137. *c*	138. *c*
139. *d*	140. *c*	141. *c*	142. *a*	143. *d*	144. *d*
145. *a*	146. *a*	147. *a*	148. *b*	149. *d*	150. *c*

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 65

151. An engine in which the burning of the fuel takes place within the engine cylinders and not at some outside source.

152. The purpose of an internal-combustion engine is to convert heat energy into mechanical energy.

153. The term *cycle* means the completion of a series of events in the cylinder necessary to deliver continuous power to the crankshaft.

154. Knuckle pins are lubricated by oil, under pressure.

155. Knuckle pins are held in place by a lock plate and screw; the screw should always be safety wired.

156. It is necessary to fill exhaust valves with a sodium solution because the sodium solution greatly assists in reducing the operating temperature of the valve.

157. Some of the reasons why valves warp are inadequate cooling and overheating.

158. Crankshafts are checked for runout by the use of a dial gauge.

159. Two clearances that must be checked are end clearance and side clearance, to allow for expansion.

160. A leak in the intake pipe would cause too lean a mixture and a rough-running engine, most noticeable at low speeds.

161. Intake valves are timed to open before top dead center on the exhaust stroke, to help push out the remaining exhaust gas, and are timed to close after bottom dead center, to promote more volumetric efficiency.

162. Exhaust valves are timed to close after top center on the intake stroke, to afford a better volumetric efficiency; this is known as valve overlap.

163. Compression ratio is the ratio between the space above the head of the piston when it is at *bottom dead center* to the space above it when it moves to *top dead center*. The compression ratio of most aircraft engines varies from 5 to 7. For example: In a cylinder having a piston displacement of 100

cu. in. and a combustion-chamber space of 20 cu. in., the compression ratio would be commonly written as 6 to 1.

Formula:

$$\frac{100 + 20}{20} = \frac{120}{20} = \frac{6}{1}$$

164. The term *volumetric efficiency* means the cubic-inch volume of fuel and air drawn into the cylinder compared to its piston displacement.

165. A supercharger is used to increase the volumetric efficiency of an engine.

166. Indicated horsepower is the horsepower developed within the cylinders of the engine.

Formula:

$$\text{i.hp.} = \frac{PLANK}{33{,}000}$$

where P = i.m.e.p.
L = length of stroke, feet.
A = area of cylinder, square inches.
N = number of power strokes per minute ($\frac{1}{2}$ r.p.m. for four-cycle engine).
K = Number of cylinders on engine.

167. The term *friction horsepower* means the horsepower necessary to overcome the friction of the moving parts of the engine, including the accessories.

Formula: $$\text{b.hp.} = \text{i.hp.} - \text{f.hp.}$$

The difference between indicated horsepower (i.hp.) and brake horsepower (b.hp.) is designated as friction horsepower (f.hp.), which can be obtained only from an actual brake test. When any two of these three horsepowers are known, the third may be obtained by the use of the above formula.

168. Brake horsepower is the actual horsepower available at the propeller shaft to do work.

169. 1L 6R 5L 2R 3L 4R 6L 1R 2L 5R 4L 3R

L = left
R = right

170. A friction clutch is usually incorporated in an aircraft engine to relieve gear stresses in the impeller gearing.

171. Relief valves are adjusted on most aircraft engines by increasing or decreasing the spring tension on the relief valves.

172. It is always advisable to remove the accessories first during disassembly of an engine, so as to prevent damage to them.

173. In the installing of a new piston ring in a cylinder, great care must be taken to assure the proper gap or end clearance. This end or gap clearance would be measured with a feeler gauge. It is recommended that piston rings be lapped in their respective cylinders with a dummy or scrap piston. A fine valve-lapping compound diluted with a little kerosene and oil should be used. They should be lapped until the original toolmarks on the outside surface have practically disappeared and the surface assumes a smooth finish. If you find that the gap is too small, it can be enlarged by filing the ends of the ring. To make certain of these points and of the piston-ring arrangement, the manufacturer's overhaul manual and service bulletins should be consulted.

174. To relieve any internal pressures that may buildup in the engine crankcase.

175. Most modern aircraft engines incorporate the dry-sump system. Three types of oiling systems for internal combustion engines are (*a*) dry sump, (*b*) wet sump (as in automobile engines) (*c*) oil-loss system (such as would be found in most outboard motors or any engine where the oil is mixed directly with the gasoline).

176. Air deflectors or pressure baffles are used in high-performance, air-cooled aircraft engines to afford better cooling of the engine while the ship is in the air. It is always

to be remembered that a tightly baffled engine depends on its cooling from the forward speed of the plane, therefore a baffled engine should never be run too long or too fast on the ground.

177. Pressure baffles have a disadvantage in that prolonged ground running will greatly overheat the engine. Therefore great caution must be exercised not to exceed the manufacturer's stipulated temperatures for ground runup.

178. The inspection requirements for all drain plugs and oil cocks are that they shall be safetied (drain plugs, tight and safetied; oil cocks, in the "off" position and safetied). This should always be noted during the pre-flight inspection.

179. Oil screens and Cuno strainers should always be removed, after the ground test, and cleaned. The oil should also be changed before the flight test.

180. If the valve clearances are too great, the valves would open too late, causing rough running due to insufficient volumetric efficiency. If the valve clearances are too small, it would result in a loss of compression and burned valves, which would cause mechanical failure.

181. The purposes of a piston are (*a*) to act as a plunger, (*b*) to draw in fuel, (*c*) to compress it, (*d*) to deliver power to the crankshaft, (*e*) to remove exhaust gases.

182. Three different types of piston pins are (*a*) stationary, (*b*) oscillating, (*c*) full floating.

183. The purpose of a connecting rod is to transmit power from the piston to the crankshaft, or vice versa.

184. Three methods of installing a full-floating pin in a piston to prevent scoring of the cylinder are (*a*) aluminum plug, (*b*) circlip, (*c*) endless spiral coil.

185. The firing order of a six-cylinder in-line engine is 1-5-3-6-2-4.

186. The procedure for adjusting valve clearances (cold) is as follows: (*a*) Remove all rocker box covers, (*b*) turn the engine in its normal rotation until No. 1 piston is at top dead center on the compression stroke (in this position, both valves

are closed and have the maximum cold clearance). The correct cold clearance will be found on the engine data plate. A feeler gauge, corresponding in thickness with the correct *cold* clearance, is inserted between the top of the valve and the rocker arm. The valve adjusting screw, lock nut, or lock screw is then tightened snugly. (Care must be taken not to turn the adjusting screw while tightening the lock nut.) After the lock nut is tightened, the clearance of the valve should again be checked. Repeat the same procedure for all valves following the firing order of the engine. For example: For a nine-cylinder engine, the valves would be adjusted in the following rotation: 1-3-5-7-9-2-4-6-8, always making sure that the piston of the cylinder that is being worked on is at top dead center of the compression stroke.

187. Two procedures for checking an exhaust valve for blow-by are (*a*) by a suitable compression gauge, (*b*) by listening at the exhaust stack while an assistant pulls the engine through by hand.

188. A general trouble is a trouble that affects all the cylinders on the engine (such as faulty carburetion). A local trouble is a trouble that affects only one or more cylinders (such as a faulty spark plug).

189. The purpose of the turbosupercharger is to create greater volumetric efficiency, or to assure sea-level pressures at the carburetor inlet at high altitudes.

190. The turbosupercharger gets its power by utilizing the exhaust pressure.

191. The difference between a preheater and a hot spot is that (*a*) a preheater heats the air before it enters the carburetor, (*b*) a hot spot heats the fuel-and-air mixture after it leaves the carburetor, aiding in better vaporization of the fuel.

192. Four methods of starting an aircraft engine are (*a*) by hand, (*b*) by inertia starter (hand), (*c*) by cartridge starter, (*d*) by electric inertia or direct-drive electric.

193. The inside surfaces of cylinders on aircraft engines are processed or nitrided to reduce wear of the cylinder barrel.

194. The rear row of cylinders (or *rear bank*, as it is commonly called) has the odd numbers on a twin-row radial engine.

195. The general procedure for checking ignition timing on most aircraft engines (radial) is as follows: Turn the engine slowly in the direction of normal running rotation until the piston of No. 1 cylinder is at top dead center on the compression stroke. (If the timing marks on the engine are not accessible, it will be necessary to use a timing disk.) Next, consult the manufacturer's manual for the proper specifications for timing. Most aircraft engines are timed from 28 to 33 deg. before top dead center. Having determined the exact setting in degrees, back the engine (opposite of rotation) until either the timing disk or the manufacturer's marks line up properly. Remove the distributor blocks and turn the magneto in the direction of normal rotation until the timing mark on the ring of the large distributor gear corresponds with those on the machine surface of the front end plate. There are two sets of these timing marks, consisting of one and two lines each; therefore, make sure, when timing, to line up the proper marks. When this is done, engage the magneto coupling to the engine magneto drive gear. There are several methods that can be used for checking to see that the magneto points open at the proper time, such as strips of cellophane between the breaker points or a suitable timing light. This procedure is for a pivot-type magneto and not a pivotless type. If not experienced in this, be sure to consult the manufacturer's manual for further details.

196. b.hp. = brake horsepower; m.e.p. = mean effective pressure; TDC = top dead center; CAT = carburetor air temperature; i.m.e.p. = indicated mean effective pressure.

197. Maximum power is take-off power and should not be used for a period of more than 5 min. Rated power is the pawer guaranteed by the manufacturer. This power may be used as long as the temperatures stay within their specified limits. These temperatures vary and the manufacturer's

manual should always be consulted for the type of engine being used.

198. Detonation is the uncontrolled burning of fuel in the combustion chamber.

199. Mechanical failure is the effect of severe or prolonged detonation.

200. i.hp. (indicated horsepower) is always higher in an engine.

CHAPTER III

LUBRICATION AND OILING SYSTEMS

LUBRICATING OIL

Functions.—The lubricating oil functions to lubricate, cool, seal, and scavenge the engine. Mineral oil, refined from petroleum, is in use at the present time. Various synthetics have been added the better to control the viscosity range of the lubricant.

Lubrication.—Oil serves to separate metal surfaces, so that metallic contact does not occur. An oil film must be present or rapid wear will result.

Physical Characteristics of Oil.—Among the physical characteristics of oil are its viscosity, susceptibility to ignition, and chemical stability. (1) Viscosity is the resistance of the oil itself to flowing. High-viscosity oil flows slowly. Low-viscosity oil flows readily. Temperature affects viscosity. Hot oil flows more readily than cold oil. Airplane engine oil is designed to function within the temperature range of about 300°F. (2) Flash point is the degree of temperature at which an oil will momentarily ignite. (3) Chemical stability is the ability to resist oxidation, moisture, acids, and high temperatures.

Cooling.—Oil cooling is accomplished by conducting the heat away from the engine. In turn, the oil itself must be cooled. This cooling takes place in an oil radiator, thermostatically operated.

Sealing.—Sealing takes place in the cylinder walls and rings. A film of oil prevents rapid wear and attendant blow-by, by effectively sealing piston rings and cylinder walls.

Scavenging.—The scavenging of dirt, carbon, metal particles, water, etc., occurs when the oil picks up these substances in

the engine. The oil is led through suitable filters and strainers to remove such particles.

MODERN LUBRICATION SYSTEMS

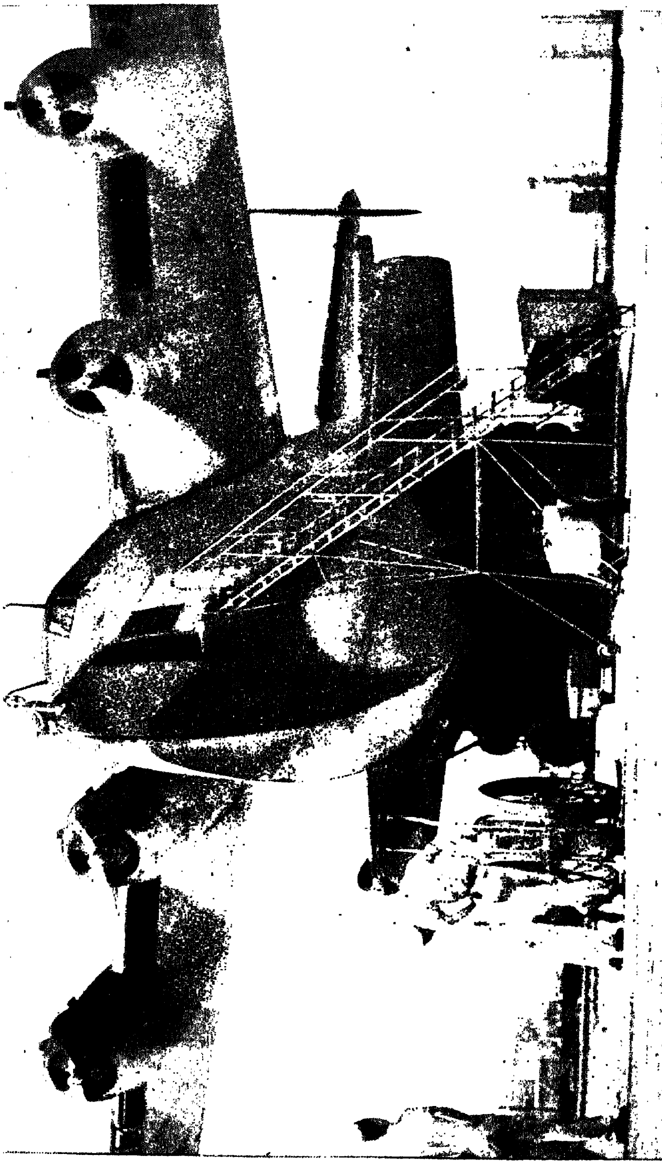
Modern lubrication systems consist of (1) the external supply tank, (2) suitable oil lines and fittings, (3) the oil temperature regulator, (4) the oil pressure pump and relief valve, (5) oil scavenger pumps, (6) temperature and pressure gauges, (7) oil dilution systems.

Pressure-fed, Dry-sump Type.—All high-power engines use the pressure-feed, dry-sump type of lubrication system. A dry-sump system is one in which the oil is carried in a separate supply tank outside the engine. The oil is drawn from this tank by the pressure pump and is fed to the crankshaft under pressure. As the excess oil leaves the crankshaft and bearings, it is thrown around in the engine crankcase by the rapidly moving parts. This is known as splash. Certain parts have oil sprayed directly over them. This is known as spray. All internal parts are bathed in an oil mist resulting from the high temperatures and pressures of the oil.

Scavenging Pumps.—To conduct the oil from the engine, one or more scavenging pumps function to return the oil to the supply tank. These pumps must be of ample capacity to assure crankcase scavenging under all flight attitudes.

Oil Temperature Regulator.—The oil cooler or oil temperature regulator serves to cool the oil to safe temperatures before it is reused by the engine. These regulators also serve to warm up the oil rapidly when it is cold, by returning the oil used directly to the engine to aid in warming it to a predetermined value. They are automatic in operation. They consist of a jacket and core and a thermostatically operating valve to direct the oil flow.

Pressure Relief Valve.—The oil pressure relief valve functions to maintain a constant pressure by relieving excessive pressure. Adjustment is obtained by an adjusting screw on the spring-loaded relief valve. A crankcase breather is provided to



Roaring in unison are the engines of this Pan American clipper during a pre-flight run-up at La Guardia Field New York

prevent the building up of pressure in the crankcase, and suitable oil filters are incórporated to strain impurities from the oil.

Filters.—Most oil filters are of the disk type. They consist of disks and spacers forming a fine-mesh screen. Engine oil must pass between the disks, and this effectively filters solid contaminant from the oil. Modern filters rotate automatically, operating by engine oil pressure. In the event that the filter becomes inoperative because of dirt, etc., a by-pass valve opens to permit lubrication of the engine, as dirty oil is more desirable than no oil.

Pressure Gauge.—The oil pressure gauge connection should be connected at a point beyond the filter, to ensure accurate pressure readings. The oil temperature connection is on the oil-in side of the system. The principal reason is to determine the oil temperature (and therefore its viscosity) as it enters the engine.

Tanks.—Oil tanks are of aluminum or stainless-steel construction. They are provided with baffles, to strengthen the tank and resist the surging of the oil. An expansion tank is provided, which may not be inadvertently filled with oil.

Other Equipment.—A vent and filler cap, a suitable measuring stick, a screened outlet and drain fitting complete the assembly.

MAINTENANCE

Radial and inverted engines should always be pulled through by hand before starting if the engine has been idle one hour or more. The switch must be "off" and the propeller pulled through several times to make sure that the oil has not drained into the cylinders. If a quantity of oil is present in the lower cylinders, considerable damage may result.

Upon starting the engine, the oil pressure gauge should be watched to ascertain proper functioning of the system. Oil pressure should show in 15 sec. operation. If it does not

register within 30 sec., the engine should be stopped and the cause investigated.

The engine should be warmed up slowly, to allow proper expansion of the parts, adequate oil pressure to build up, and the oil to attain its proper viscosity as a result of its warming up. Maximum warm-up speed should never be exceeded until the oil reaches minimum temperatures and pressure.

Oil draining periods are specified by the manufacturer. Modern oil dilution systems have obviated seasonal oil changes.

OIL DILUTION SYSTEMS

Quick starting and rapid warm-up are accomplished in these systems by diluting circulating engine oil prior to stopping the engine when cold starts are anticipated.

A hopper tank is employed to circulate the small portion of the oil supply that is diluted by the operator. Dilution takes place by operating a valve to feed gasoline directly into the oil system. An electrically or manually operated valve may be used. The amount of dilution depends upon the gasoline rate of flow, the amount of oil to be thinned, and the degree of dilution necessary. The capacity of the hopper tank is about 1½ gal.

As a result of the higher operating ranges of aircraft engines, the heat drives off all gasoline dilution from the oil in a short time. Some temperature regulators employ a viscosity valve to aid in maintaining proper viscosity of the oil as the diluted oil is used.

MULTIPLE-CHOICE QUESTIONS*

1. The type of lubrication system most commonly used in aviation engines is

a. wet sump
b. the splash
c. the splash circulating

* A key to the answers is given on p. 96.

d. the full pressure
e. a combination of splash and pressure

2. The purpose of a pressure relief valve is to
a. by-pass oil around the pump
b. by-pass oil around the radiator when it becomes clogged
c. maintain a constant pressure of oil on the bearings in the engine by relieving excessive pressure
d. relieve high pressures in the tank and prevent failure
e. help to warm up the oil more quickly after starting

3. The capacity of a lubrication system shall be
a. not less than .15 lb. per maximum horsepower
b. as specified by the engine manufacturer
c. not less than 1 gal. for each 75 hp.
d. large enough to maintain proper lubrication for as long as the fuel lasts under normal operating conditions
e. twice as much as necessary for take-off horsepower

4. One cause of an engine's developing low oil pressure would be
a. oil supply low
b. scavenger pump not operating properly
c. improper grade of oil being used
d. pump failure
e. shear pin broken in the pump shaft

5. The type of oil best suited for an engine having a chronic high oil pressure is one with a
a. high flash point
b. low pour point
c. high viscosity
d. low viscosity
e. low flash point

6. Excessive wear on a master-rod bearing would cause
a. excessive oil consumption
b. lowering of the oil pressure
c. excessive accumulation of oil in the sump
d. the pressure relief valve to fail

7. The reason for locating the oil supply tank externally on a radial engine is

a. to prevent thermal expansion due to close approximation to engine

b. to house an independent supply of oil

c. to conform to the dynamic balance of the engine

d. to house the oil from the scavenger pump because the location of cylinders does not permit the use of a wet sump

8. A low oil pressure may be caused by

a. slight wearing of the bearings

b. slightly worn gears in the scavenger pump

c. use of too heavy an oil

d. stopped-up vent from tank

e. use of too light an oil

9. If an engine has been operating with proper oil pressure but suddenly shows a great deal of fluctuation in the pressure, the first thing to do is to

a. look for a broken pressure relief valve spring

b. look for leaky suction lines to the pressure pump

c. see if the pressure pump is primed

d. check the scavenger pump

e. check the oil supply in the tank

10. The normal operating temperature for oil in an aviation engine may be

a. 60 to 80°F.

b. 65 to 80°C.

c. 100 to 120°C.

d. 140 to 160°C.

e. 100 to 120°F.

11. If the oil temperature should run too high, it might be caused by

a. too high an oil pressure

b. too heavy a grade of oil

c. low oil level in the tank

d. too high an oil level in the tank, causing a high pressure to be built up
e. failure of the scavenger pump

12. The radiator used for cooling oil is found
a. between the automatic temperature regulator and the engine pump
b. between the engine pump and the indicator
c. between the supply tank and the temperature regulator
d. between the supply tank and the indicator
e. between any two parts of the lubricating system

13. The scavenger system is
a. of greater capacity than the pressure system
b. of smaller capacity than the pressure system
c. of equal capacity with the pressure system
d. of greater pressure than the pressure system
e. of less pressure than the pressure system

14. The ability of oil to flow is called
a. permeability
b. adhesiveness
c. viscosity
d. acidity
e. factor
f. pressure factor

15. Besides lubricating the engine, the lubricating system
a. affords smoothness and ease of operation when the engine is cold
b. prevents the seizing of moving parts of the engine when excessive temperatures are reached
c. acts as a means of conducting heat
d. carries off particles of dirt
e. heats moving parts, to prevent excessive clearances at extremely low temperatures

16. The scavenger pump in aviation engines is frequently larger than the pressure pump because
a. the tank is installed higher than the pumps, requiring a greater capacity to lift the oil to the top of the tank

b. the scavenger pump has to lift the oil from the sump
c. this will prevent excessive oil from accumulating in the crankcase
d. the oil expands when heated, and so requires a larger pump
e. a higher pressure is built up in the return line because of radiators and strainers

17. The volume of the expansion space in an oil tank shall be
a. ½ gal.
b. ½ gal. for each 75 hp.
c. at least 10 per cent of the capacity of the system
d. at least 1 gal. for every 20 gal. of fuel
e. as the manufacturer specifies

18. The reason for annealing fuel and oil lines is
a. to prevent cracking when bending
b. to allow for reinstalling without damaging fittings
c. to prevent vibratory crystallization
d. to prevent clogging under high pressures
e. to maintain proper length under high temperatures

19. Excessive leakage of oil from the breather openings on an engine may be caused by
a. leaky pistons causing blow-by
b. too high an oil pressure
c. too much oil spray in the crankcase
d. excessive foaming, causing high pressure in the tank
e. stopped-up vent line

20. When an engine is overhauled, all oil passages should
a. be plugged so that they will hold the oil
b. be filled with oil so that the bearings will have proper lubrication when the engine is started
c. be cleaned with a piece of wire
d. be thoroughly cleaned with compressed air and cleaning fluid
e. have oil passed through them and, if any oil comes through, passed on inspection

21. The reason for vents on oil tanks is

a. to prevent overflow at filling
b. to allow for expansion caused by overheating
c. to prevent excessive pressure build-up in the oil tanks
d. to prevent the clogging of lines when the oil is cold
e. to allow thermoexpansion of the oil

22. The purpose of a relief valve in an oil radiator is to

a. prevent excessively high pressure in the oil radiator
b. prevent the oil pressure's reaching minimum pressure by adding pressure through the by-pass
c. by-pass the oil until a sufficiently high temperature is reached
d. short-circuit the flow if the radiator becomes clogged
e. by-pass the pressure from the reservoir if the pump fails

23. A pressure relief, or by-pass, valve is sometimes used at the oil cooler

a. because the scavenger pump is larger than the pressure pump and may cause high pressures in the lines
b. to by-pass oil around the radiator when it is clogged
c. to maintain a constant pressure in the lines
d. to reduce foaming in the lines
e. to keep the scavenger pump prime

24. Oil lines used in aircraft are usually

a. copper or aluminum lines connected with hose connections
b. special rubber hose
c. copper or aluminum lines connected with rigid connections
d. special flexible metal hose
e. stainless-steel tubing with rigid connections

25. Gears of an oil pump having too much side clearance will cause

a. a reversal of flow in oil lines
b. failure to reach proper oil pressure
c. excessive increase in pressure

d. the pump to vibrate excessively
e. the pump to pulsate excessively at delivery

26. A Cuno is used to
a. keep magnetos synchronized
b. filter oil
c. regulate flow of fuel when the airplane is in a vertical bank
d. prevent excessive temperature rise in the cylinder heads
e. prevent static through high-tension lines

27. The oil tank should be able to stand an internal test pressure of
a. 3½ lb. per sq. in.
b. 5 lb. per sq. in.
c. 10 lb. per sq. in.
d. 40–60 lb. per sq. in.
e. 1 lb. per sq. in.

28. Oil pressure should be taken at the
a. inlet to the engine
b. inlet to the tank
c. outlet from the tank
d. inlet to the cooler
e. inlet to the temperature control

29. When, upon an engine's being installed, the pump fails to deliver oil, you should
a. check tooth alignment in the pump
b. check the relief valve for spring failure
c. prime the pump
d. determine the condition of the shear pin
e. examine the accessary drive shaft for worn bushings

30. If a relief valve fails and the oil supply becomes excessive, it will cause
a. excessive smoking of the engine because of oil's passing the rings and getting into the combustion chamber
b. fouling of the spark plugs
c. high oil consumption

d. rupture of oil lines or fittings
e. the shear pin's breaking on the pump shaft

31. Larger clearances are found between bearings and journals on aircraft engines than on automobile engines because

a. the engine is higher per horsepower and needs better lubrication
b. a heavier oil is used
c. they are heavy-duty engines
d. clearances are not greater but smaller
e. the heavier oils are of better quality

32. The lubrication system for an aircraft engine should hold at least

a. twice as much as necessary for take-off horsepower
b. as much as is specified by the aircraft manufacturers
c. 1 gal. for each 20 gal. of fuel capacity
d. a safe amount to maintain proper lubrication for the cruising range of the aircraft
e. 1 gal.

33. High oil consumption may be caused by

a. too low oil pressure
b. leaky oil pressure relief valve
c. worn oil pump
d. worn connecting-rod bearings
e. worn main roller bearings

34. Prevention of cylinder flooding is accomplished on an inverted engine by

a. having the drains to the scavenging pump located at a point opposite the oiled wiper rings on the piston
b. regulating the pressure to a minimum, so that there will be no excessive oil
c. having the pistons' skirts extend into the crank-case, and draining the oil around the skirts to the outlet
d. adding extra oil-wiping rings on inverted engines that have a pressure system
e. drilling ring grooves closer on the inverted engine

35. When an oil pressure gauge needle fluctuates excessively on a perfect gauge, the trouble, most likely, is

a. broken teeth on pump gears
b. failing supply of oil
c. improper grade of oil in the tank
d. air leak in the pressure line
e. broken pressure gauge snubber

36. The lowest temperature at which vapor produced by heating a sample of oil will ignite, without setting fire to the oil, is called

a. the pour point
b. the fire point
c. the flash point
d. the viscosity point
e. the pyromic point

37. Too high an oil pressure may cause

a. excessive oil pumping into the combustion chamber
b. oil accumulation in the crankcase
c. too much lubrication of the bearings
d. broken or weakened oil pressure relief valve springs
e. overheating of the oil

38. Blue smoke from the exhaust may be caused by

a. worn oil pressure pump
b. too high a fuel pressure
c. excessive clearance of main and connecting-rod bearings
d. too low an oil pressure
e. low oil level in tank

39. Oil is prevented from excessively coating the cylinder walls by

a. keeping the oil at a required temperature
b. preventing the pressure from becoming too high
c. the pressure relief valve
d. the pressure regulator
e. oil wiper rings

40. Fouling of spark plugs may be caused by

a. a broken wiper ring on a piston

b. oil temperature that is too low
c. faulty relief-valve springs
d. air leak in the scavenger line
e. use of oil having the wrong flash point

41. Accumulation of oil in the crankcase may be caused by
a. leaky oil lines to the scavenger pump
b. clogged oil cooler
c. improperly operating cooler by-pass valve
d. pressure relief valve allowing too much oil into the crankcase
e. oil pumping by the piston

42. The accumulation of oil in the crankcase while the engine is idle is sometimes prevented by
a. using a lower oil level in the tank
b. installing the tank at a lower level
c. using heavier oil
d. installing a check valve in the oil pressure passage or inlet line
e. using a larger scavenger pump

43. The best type of oil for aviation engines is
a. organic
b. animal
c. vegetable
d. castor
e. mineral

44. When oil lines are connected between the tank and the engine, you are cautioned to
a. protect the lines from excessive heat transfer from the engine
b. ensure against vapor locking
c. install proper grommets
d. see that they are braced to prevent vibration and wear
e. be sure of proper diameter to conform with the CAA

45. The inlet and outlet oil connections on an oil tank are widely separated so as to
a. afford cooling of the oil before it returns to the engine

b. prevent air bubbles entering feed lines
c. increase oil supply to the tank
d. prevent centrifuging of the tank
e. prevent pressure build-up in the pressure lines

46. Water is likely to accumulate in the lubrication system as a result of
a. too much blow-by past the pistons
b. condensation due to intermittent operation in cold weather
c. operation of the engine in damp weather or rain
d. carelessness in filling
e. storage of the plane outside

47. When existing climatic temperatures warrant the use of an oil of higher viscosity than the oil that is being used, it becomes evident by
a. fluctuation of the gauge needle
b. an appreciable loss of power
c. abnormal rise in the oil temperature
d. excessive vapor locking
e. emulsioning of pump gears

48. Too high an oil pressure may cause
a. carbon formation in the combustion chamber
b. broken piston rings
c. high pressure in the oil tank
d. failure of the oil cooler
e. failure of bearings resulting from high pressure

49. An engine exhausting blue smoke would indicate
a. oil pressure too high
b. oil pressure too low
c. wrong viscosity of oil
d. mixture too rich
e. worn piston rings

50. If a crankcase breather expels oil, the cause may be
a. a worn master-rod bearing
b. worn piston rings

c. high oil pressure
d. oil viscosity too low
e. a broken oil line

51. If metal is found in an oil screen, you should
a. dismantle the engine
b. disregard it, not being important
c. thoroughly inspect the internal parts of the engine
d. change the oil
e. thoroughly clean the screen and replace it

52. A rise in oil temperature accompanied by a pressure drop would indicate that
a. oil viscosity is below recommended value
b. flash point of oil has been reached
c. pressure relief valve is stuck open
d. oil radiator relief valve is stuck open
e. radiator is clogged

53. The oil passages in the internal parts of an engine when overhauled should be
a. rebored to a slightly oversized diameter
b. sealed to prevent the entrance of foreign particles
c. thoroughly cleaned with a suitable sludge solvent under pressure
d. filled with molten wax to prevent dirt accumulation
e. checked for symmetry

54. A radial engine is equipped with a scavenger pump so that
a. the oil can be removed from the sump
b. the oil pressure can be boosted
c. the pressure pump can be primed
d. pressure can be prevented from rising above a predetermined point

55. If the oil is retained in the crankcase of a radial engine, the cause may be
a. excessive expansion of oil because of heat
b. stuck wiper rings on the piston skirt
c. excessive oil supply

d. improper priming in the scavenger pump
e. a faulty relief valve

56. The reason for using high-viscosity oil in aircraft engines is due to
a. high temperatures and large clearances
b. greater flowing qualities
c. small clearances
d. development of higher r.p.m.
e. better lubricating qualities

57. An overhead oiling system is a system in which
a. an inverted engine is oiled
b. a radial engine is oiled
c. the rocker arms are greased
d. oil is forced to the valves
e. cylinder walls are oiled

58. To create a change in the oil pressure, it is necessary to
a. change the oil pressure gauge
b. increase the oil-line diameter
c. change the relief valve setting
d. use oil of a different viscosity
e. change the speed of the oil pump drive

59. With an appreciable increase in the oil temperature in an otherwise normally operating radial engine the cause may be
a. improper scavenging of the oil overhead oiling system
b. improper oil-line diameter
c. not enough cooling area for the oil radiator
d. defective scavenging system
e. the use of spark plugs of the wrong type

60. When inspecting an engine driven gear pump for pressure and volume, you should
a. inspect the condition and clearance of the gears
b. block off one end of the line and measure the maximum pressure that the pump can deliver
c. inspect fittings for leaks and check all radial bends for kinks

d. inspect the side clearance of the gears, shear pin, and pump-shaft coupling
e. block up both inlet and outlet and test with a hand pressure pump

61. Oil lines are lagged on aircraft engines to
a. retard the flow of oil
b. prevent friction between the oil lines and structural parts of the airplane
c. prevent dissipation of heat in cold weather
d. prevent crystallization of the tubing
e. have a bonding effect

62. The air space required in the oil supply tanks is to
a. allow for expansion of heated air
b. house excess oil
c. allow for thermal expansion of the oil
d. aid in cooling the oil
e. allow for foaming

63. The reason for the absence of a scavenger pump on a wet-sump engine is that
a. the oil remains in the crankcase
b. the oil returns to the tank by force of gravity
c. the oil is consumed faster because of higher speeds and greater temperatures of the engines
d. the oil returns to the tank by force of a gravity pump
e. the crankcase is situated higher in a wet-sump engine

64. Oil radiators are required on
a. engines of 100 hp. or more
b. all engines
c. supercharged engines
d. no engines
e. engines using controllable-pitch propellers

65. A check valve on the inlet side of a pump is to
a. prevent sludge entering the pump
b. prevent a reversal of flow when the pump is not operating
c. regulate the flow of oil

d. by-pass oil when the temperature is too high
e. maintain a predetermined pressure

66. If two lengths of oil lines are to be connected with rubber hose
a. they must be properly bonded
b. they should be made airtight and leakproof
c. they should have metal liners under the hose
d. sufficient clearance should be left between tube ends

67. Oil lines are lagged with
a. friction tape and shellac
b. friction tape and cement
c. asbestos tape
d. lagging strips
e. wing tape and dope

68. Worn connecting-rod bearings in an engine cause
a. failure of the engine
b. knocking
c. overheating
d. loss of r.p.m.
e. too high an oil consumption

69. Modern engines incorporate oil dilution systems to
a. dilute the oil in hot weather
b. prevent pressures building up in the crankcase
c. aid in rapid scavenging
d. assist in easy starting during cold-weather operation
e. prevent the fumes from reaching the pilot

70. If a Cuno oil strainer clogged up, what would happen?
a. the engine bearings would burn out
b. the oil would be by-passed around the screen
c. the pressure would burst the Cuno
d. the engine would be lubricated by splash

71. An advantage of a hopper-tank dilution system is that
a. it aids in flushing metallic particles from the sump
b. oil does not require changing
c. oil should be changed only every 50 hr.

d. oil should be changed seasonally
e. oil should be changed only at engine change

72. The main and connecting-rod bearings on a pressure-lubrication engine are oiled by

a. a stream of oil fed by an open line and spraying the master rod
b. oil scooped out of the sump
c. oil passing through the drill passages in the crankshaft
d. sealed self-oiling bearings

73. What type of bearings requires the least lubrication?

a. plain
b. roller
c. ball
d. needle

74. How are link pins lubricated?

a. by pressure
b. by splash or spray
c. by oil mist
d. by a hand oilcan used by a gremlin

75. Where in the lubrication system would you install an oil temperature regulator?

a. between the oil tank and the pressure pump
b. between the pressure pump and the engine bearings
c. between the oil sump and the scavenger pump
d. between the scavenger pump and the supply tank
e. between the oil radiator and the engine thermometer

ESSAY-TYPE QUESTIONS*

76. After the oil is drained from the Y drain, where else would you drain oil in order to drain the system completely?

77. After an oil change why is it necessary to remove the oil pressure relief valve and turn the engine over by hand?

78. After an oil change why is it a good practice to disconnect the oil line from the inlet side of the oil pump and to drain off approximately 1 gal. of oil?

* Answers are given on p. 96.

79. What is the first instrument gauge to watch after starting an engine?

80. How soon after starting an engine can you exceed one-half of the permissible ground r.p.m.?

81. Give three reasons why oil lines are bonded.

82. How are fuel and oil lines supported to a structural member?

83. Name 10 color markings and tell what they represent.

84. Before starting an engine after installation, why is it necessary to remove one spark plug from each cylinder and turn the propeller by hand at least four or five revolutions?

85. List at least six things that must be done when preparing an engine for service after it has had the storage treatment.

86. When preparing a newly overhauled engine for installation, when and why are the bottom intake pipes removed?

87. Explain how you would spray the cylinders when giving an engine a storage treatment prior to shipping.

88. Name the principal points to be checked and inspected on oil systems.

89. Why must oil tanks have an allowance for expansion? How much of an allowance is required?

90. Where would you expect to find the oil drain cock?

91. Name four purposes of oil in an aircraft engine.

92. What would cause oil to overheat?

93. What is the purpose of the shutter on the exit side of the oil regulator core?

94. What type of gauge would you expect to find to register oil pressure?

95. Why must there be two vent lines in the engine crankcase leading to the oil supply tank?

96. Would you expect to find the thermometer bulb in the oil inlet line, or the oil return line? Why?

97. Why do some installations employ an emergency oil shut-off operated from the cockpit?

98. What are two ways of determining the oil content of an oil supply tank?

99. Name two types of oil pressure gauges.

100. What is the purpose of a thermostatic valve incorporated in an oil system?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 79

1. *e*	2. *c*	3. *c*	4. *a*	5. *d*	6. *a*
7. *b*	8. *e*	9. *a*	10. *b*	11. *c*	12. *c*
13. *a*	14. *c*	15. *c*	16. *c*	17. *c*	18. *c*
19 *a*	20. *b*	21. *c*	22. *a*	23. *b*	24. *a*
25. *b*	26. *b*	27. *a*	28. *a*	29. *c*	30. *a*
31. *b*	32. *c*	33. *d*	34. *c*	35. *b*	36. *c*
37. *a*	38. *c*	39. *e*	40. *d*	41. *a*	42. *d*
43. *e*	44. *d*	45. *b*	46. *b*	47. *c*	48. *a*
49. *e*	50. *b*	51. *c*	52. *e*	53. *c*	54. *a*
55. *d*	56. *a*	57. *d*	58. *c*	59. *d*	60. *a*
61. *c*	62. *c*	63. *a*	64. *d*	65. *b*	66. *c*
67. *c*	68. *e*	69. *d*	70. *b*	71. *e*	72. *c*
73. *c*	74. *a*	75. *d*			

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 94

76. You would also remove the plug from the oil coolers in order to drain them. The engine sump also should be drained and the Cuno strainer should be removed and cleaned.

77. It is a good practice to make sure that the oil is circulating through the engine. This will be indicated by the oil's running out of the relief valve housing. This is known as pre-oiling.

78. It is a good practice to drain off approximately 1 gal. of oil to make sure that the oil is going to the pump. This will also eliminate bubbles and trapped air. This ensures an engine of good initial lubrication when it is first started after an oil change.

79. The first gauge to watch after starting an engine is the oil pressure gauge; if it does not show any pressure in approximately 30 sec., immediately shut off the engine and determine the cause.

80. You should not exceed one-half of the permissible ground r.p.m. until the oil pressure is at least two-thirds of

normal minimum full-power pressure and a definite temperature increase is noted.

81. Three reasons why oil lines are bonded are (*a*) to increase the electrical capacity of the radio antenna, (*b*) to increase the electrical capacity of the transmitting set, (*c*) to eliminate the danger of sparks arcing between the metal structural members.

82. Fuel lines are supported to structural members by taping, clamping, or by using new bonding clamps, which bond and support the lines in one operation.

83. (*a*) red—indicates fuel lines, (*b*) yellow—indicates oil lines, (*c*) white—indicates water coolant, (*d*) white-black-white—indicates Prestone coolant, (*e*) green—indicates oxygen, (*f*) blue and white—indicates manifold pressure, (*g*) blue and yellow—indicates bilge (*h*) green and white—indicates vacuum, (*i*) orange—indicates supercharger, (*j*) blue and black—indicates steam heating.

84. It is necessary to remove a spark plug from each cylinder and turn the propeller by hand to clear the cylinders of excess storage compound, especially the lowermost cylinders of radial engines. This prevents damage to the engine when it is started.

85. Six things that should be done when preparing an engine for service after it has had a storage treatment are (*a*) Remove all oil strainers and plugs to allow the corrosion-preventive compound to drain. (*b*) Remove and clean the Cuno. (*c*) Lubricate the valve mechanism. If it is the automatic type, use 120 engine oil; if not, use rocker-arm grease. (*d*) Remove all petrolatum from the magneto breaker assembly. (*e*) Remove lowermost intake pipes, and check for excess corrosion-preventive compound. (*f*) Wash the engine down, check the valve and ignition timing.

86. The bottom intake pipes are removed, in preparing a newly overhauled engine for installation, when the engine has stood in a flying position for at least 24 hr. without the crankshaft's having been turned. They are removed to check for

excess compound being in the lower intake pipes, which might have drained from the parts of the supercharger section, thus eliminating damage to the engine when it is first started.

87. The method for spraying cylinders when giving an engine a storage treatment is as follows: Spray each cylinder 15 to 20 sec. with a corrosion-preventive compound, with the piston at bottom dead center, *intake valves open.* On air-cooled engines, spray through the front spark-plug holes. On engines of the V type, spray through the outer, or exhaust, spark-plug holes.

88. In inspecting oil systems, the principal points to be checked are as follows: All plugs and drains should be inspected carefully for leakage and proper safetying. Screens and filters should be cleaned of any dirt and sludge. The tank should be inspected for proper mounting and for signs of leaks and dents. The oil temperature regulator supports should be checked, and the core inspected for restrictions and leaks. If an oil dilution system is incorporated, the linkage should be inspected for binding and to assure that it operates freely. The oil tubing should be inspected for being properly installed and supported. The hose connections should be checked to make sure that they are in good condition, and the clamps should be tested for tightness.

89. Oil tanks must have an allowance for expansion, to prevent their overflowing when the oil expands because of heat. Ten per cent is usually allowed for expansion; that is, 10 per cent of the tank volume.

90. You would expect to find the oil drain cock in the lowest part of the oil system. This is usually known as the Y drain. By having this so located you can assure complete drainage of the oil system.

91. Four reasons for having oil in an aircraft engine are as follows: (*a*) as lubrication, to help overcome friction, (*b*) to seal in the compression, (*c*) to cool and help dissipate heat, (*d*) to clean or carry away impurities in the engine.

92. Some conditions that cause oil to overheat would be a clogged oil radiator, too low an oil supply, and worn master-rod bearings.

93. The purpose of a shutter on an oil regulator core is so that the operator may have control over the oil temperature. Where there is no provision for an oil shutter assembly, it is permissible in cold weather to blanket the core area partially with a suitable material, in order to obtain the proper oil temperatures.

94. Two types of gauges used to register oil pressure are the Bourdon tube and the Autosyn instrument.

95. Two vent lines are used and are located so that at least one vent is open in all normal flight attitudes.

96. You would expect to find the thermometer bulb in the inlet line. The temperature is taken at the inlet line to determine whether the oil has been properly cooled.

97. Some installations employ an emergency oil shutoff operated from the cockpit so that, in case of fire, the oil can be shut off between the tank and the engine.

98. Two ways of determining the oil content of an oil supply tank are by a sight gauge and by a dip stick. In most tanks the filter cap is so located that the correct level is automatically established.

99. Two types of oil pressure gauges are the Bourdon tube and the Autosyn instrument.

100. A thermostatically operated valve is incorporated in oil temperature regulators, to control the passage of oil automatically through the cooler.

CHAPTER IV

FUELS, INDUCTION AND FUEL SYSTEMS, AND CARBURETION

In general, the fuel used in an internal-combustion engine is the basic source of energy. The induction systems are means of supplying the fuel to the engine; and the carburetor, a device to mix the fuel and air in the proper proportions. The carburetor, therefore, is a metering device.

FUELS

Elements of Combustion.—Fuels may be defined as substances that, when combined with oxygen, will burn and produce heat. The heat produced is the result of a chemical reaction that converts the potential energy in the fuel into heat. This heat may be utilized, or transferred into kinetic (energy of motion). Modern fuels are refined products of petroleum. Petroleum is a mineral oil and consists mainly of various hydrocarbons. Oxygen, which is present in air to the extent of approximately 20 per cent, is essential to combustion. The remaining 80 per cent is composed chiefly of nitrogen, an inert gas, which does not enter into the process of furnishing heat. It follows that the nitrogen content of the air is detrimental to engine operation, in the sense that it is not useful. We may add that the warming up of the 80 per cent nitrogen detracts from the heat energy of the fuel.

Chemical Compounds.—Fuels (hydrocarbons) consist of an important source of heat energy. Hydrogen is a light and inflammable gas. When burned with air, it combines to form H_2O (water). Oxygen, when ignited with a sufficiency of carbon, forms carbon dioxide (CO_2). When a supply of oxygen is insufficient, carbon monoxide (CO) also will be produced.

Performance of Aircraft Fuels.—Gasoline is a blend of hydrocarbons that contains high heat units (B.t.u.'s). This heat content and availability make it suitable for aircraft fuels. All aircraft fuels should be free from water, sulphur, corrosive compounds, and gum-forming tendencies.

Volatility.—Volatility may be defined as the vapor-forming tendencies of fuels at various temperatures. This controls ease of starting, vapor lock, acceleration, oil dilution, etc. The range of volatility is held within safe limits.

Octane Rating.—Octane rating is the antiknock value of the fuel. The higher the octane rating, the less the tendency of the fuel to detonate. *Detonation* may be defined as an extremely rapid burning of the fuel. It subjects the engine to a series of mechanical shocks that may result in engine failure. Detonation may also be defined as the inability of the fuel to withstand extremes of temperature and pressure. Modern gasolines are treated and refined to minimize detonation.

Rate of Combustion.—During normal combustion, the fuel-air mixture burns evenly over a period of time. This is known as the *rate of combustion*. The heat of the burned gases further compresses the unburned mixture and raises its temperature. Under certain conditions the pressure and the temperature of the unburned charge will cause it to explode spontaneously, and this results in an extremely rapid abnormal pressure rise. The piston is unable to move fast enough to absorb the energy released, and receives a hammerlike blow.

Detonation.—This audible knocking or pinging is the result of detonation. Detonation or knocking overstresses engine parts, creates excessive engine temperatures, and can result in complete engine failure.

To prevent detonation, the octane rating of the fuel, mixture ratio, manifold pressure, cylinder temperature, carburetor air temperature, and spark timing are some of the factors to be considered. To increase the octane rating of aircraft fuels small quantities of ethyl fluid are added. Ethyl fluid contains

tetraethyl lead, ethylene, dibromide, and aniline dye. The tetraethyl lead is considered very effective in minimizing detonation.

Fuels are rated for detonation characteristics by comparison with a standard reference fuel. The reference fuels selected are different in knocking qualities, but almost identical in heat value. Normal heptane is selected for its ready knocking characteristics, while the other fuel, isooctane, is selected for its antidetonation value. A mixture of these two fuels will give a detonation ratio depending on the percentage of each.

Octane Ratings.—An octane rating of 87 per cent would mean that a mixture of 87 per cent isooctane and 13 per cent heptane would have the same knocking characteristics as the fuel tested. Contrary to popular belief, nothing will be gained by using a higher octane gasoline in an engine that is free from detonation when a lower octane fuel is used. To obtain more power from the higher octane fuel, the compression ratio or the manifold pressure would have to be increased.

The use of a leaded fuel has a corrosive action on engine parts. Trouble is also encountered by lead deposits on spark plugs. However, its antiknocking qualities overcome the disadvantages of its use.

Preignition.—Preignition should not be confused with detonation. Preignition is the igniting of the charge before the spark occurs at the spark-plug electrodes. It can be caused by carbon deposits, overheating of exhaust valves, hot spark plugs, etc. The effect is the same as advancing the spark beyond its best power position. Preignition occurs before the regularly timed spark. Detonation occurs after the charge is burning, whether it has been ignited by the spark or by means of autoignition (self-ignition). Preignition is conducive to detonation and should always be avoided.

INDUCTION SYSTEMS

The function of the induction system is to convey the charge to the cylinders, and to provide a space for vaporization.

Radial engines use individual intake pipes. In-line engines use intake manifolds. A hot spot, or heated jacket, may be incorporated in the intake system to allow either hot oil, coolant, or exhaust gases to assist in the vaporization of the mixture.

Superchargers.—Superchargers are incorporated in most engine designs. They furnish the engine, in most cases, with a greater mass of fuel and air than the engine will normally consume. Essentially, a supercharger is an air pump consisting of an impeller and a diffuser housing to force a heavier charge into the cylinders. The amount of manifold pressure depends upon the size and speed of the supercharger impeller.

As altitude is reached, atmosphere loses temperature, density, and pressure. At 20,000 ft. it is one-half sea level. At this altitude a cubic foot of air will weigh one-half as much as at sea level. This reduction of weight will result in a loss of volumetric efficiency and a corresponding loss in power output. This can be offset by the supercharger's restoring or compressing the air to its original density, or in some cases slightly higher.

A carburetor normally meters the fuel to the volume of air fed through it, without regard to the air density. Thus the mixture will become rich at altitude because of the lessening of air density. A supercharger restores the air to its original sea-level density or higher, and therefore, supplies the engine with its normal requirements. Most modern airplanes would be unable to leave the ground except for the use of the supercharger, which furnishes the full power necessary for take-off and climb.

Types.—The function of the diffuser plates, or vanes, is to convert the high velocity of the mixture to pressure. Superchargers are of two general types—the internal gear-driven impeller and the exhaust-driven turbine. The exhaust-driven turbine is directly connected to the centrifugal blower in the induction system. The speed of the impeller is regulated by the quantity and pressure of the exhaust gases fed

through the turbine. This is done by a valve called a *waste gate.*

Geared internal impellers are driven through hydraulic, friction, or spring couplings to absorb shock resulting from abrupt changes in engine r.p.m. Some superchargers have a means of changing the speed from a low to a high ratio. These are known as *two-speed* superchargers. When an exhaust-driven supercharger is used in conjunction with an internal blower, it is called a *two-stage* supercharger.

Prevention of Icing.—To prevent icing in the carburetor and the induction system, heat is applied to the incoming air before it enters the carburetor. Icing can be caused by the absorbing of the heat from the air to assist in vaporization of the fuel as it leaves the discharge nozzle of the carburetor. The temperature drop can be as great as 50°F. in an average engine. Thus, a carburetor can ice up on a fairly warm day, especially when the air contains a large amount of moisture. This rapid cooling of the air causes precipitation of the moisture in the form of ice. The formation generally builds up on the butterfly valve and, in severe cases, causes engine failure. The air preheater is a jacket through which exhaust gases are passed to warm up the incoming air. A cockpit control is provided so that heat may be applied. This heat should be used only when it is necessary to prevent icing.

Carburetor air temperatures and carburetor mixture temperatures are the indicating factors in controlling carburetor icing. Heat is applied judiciously, as a high-mixture temperature favors detonation and preignition by overheating or exceeding the initial temperature of the charge. A loss of power will also result through the expansion of the charge caused by heat and a corresponding loss in density.

Scoop ice is the formation that builds up in the air passage ahead of the hot-air intake valve. It is generally not serious and in some cases is avoided by drawing the warm air from behind the cylinders. Most engines have a ram-type air-intake scoop. This cold-air scoop faces into the propeller

Engine build-up mechanics at work. American Export Airlines, La Guardia Field, New York.

slip spring. When the airplane is flying, the air enters the scoop under considerable speed and pressure. The effect is to increase the engine horsepower as a result of the increase in manifold pressure.

Fuel-air Ratios.—The fuel-air ratio is the ratio of pounds of fuel to pounds of air in the mixture. This is sometimes expressed as an air-fuel ratio. The limits of combustion, or burning, are about 6 to 1 to 20 to 1 air-fuel ratio. The chemically correct fuel-air ratio is the ratio that provides exactly enough fuel to combine with the oxygen in the air for complete combustion. This is about 1 lb. of fuel to 15 lb. of air, or 0.067 lb. of fuel to 1 lb. of air. Rich and lean mixtures are designated from this ratio.

The best power ratio is richer than a chemically correct ratio, and the lean ratios are lesser. Because of incomplete vaporization, a slight excess of fuel is necessary in a rich position, to consume all the oxygen present. Lean mixtures burn slowly, releasing more heat to the cylinder wall, thereby causing overheating. Richer mixtures than the best power mixture cause cylinder temperatures to decrease. This is known as *fuel cooling* of the engine.

To determine fuel-air ratios, an exhaust-gas analyzer or a fuel-flow meter may be used. These instruments are covered in a later chapter. Most engines operate at automatic or full-rich ratio above 80 per cent of rated power; best power, 60 to 80 per cent; and best economy or lean mixtures, 30 to 60 per cent of rated power.

The particular conditions affecting carburetor requirements are manifold pressure, r.p.m., cylinder temperature, and atmospheric pressure.

FUEL SYSTEMS

Fuel systems are designed to store fuel in the airplane, filter it, and deliver the fuel to the carburetor at the proper flow and pressure under all conditions of flight. Various gauges indicate the proper functioning of the system.

Tanks.—Tanks are made of aluminum, synthetic rubber, plywood with rubber lining, or stainless steel. They usually incorporate baffles to provide strength and rigidity and to prevent surging of the fuel. An expansion space is usually incorporated and a vent line for discharging vapors and allowing air to enter the tank to prevent fuel locking. Most systems use a reserve tank, adequate to operate the engine at 20 min. full power.

Lines.—Fuel lines are generally of copper or aluminum-alloy tubing. They are annealed to prevent crystallization resulting from vibration and generally incorporate a flexible rubber tubing to absorb vibration and motion. A band of red paint identifies fuel lines.

Strainers.—Strainers are usually located at the tank sump, the lowest point in the system, and at the carburetor inlet. Drains are provided to remove water that may have collected.

Valves.—Fuel valves are incorporated to direct the flow of fuel from various tanks, cross feeds, shutoff valves, etc. They should operate freely with no leaking, and require very little maintenance. Various types have been developed recently that are very dependable.

Pumps.—Fuel pumps are to deliver a continuous flow of fuel to the engine. The type in use is the eccentric sliding-vane type. These may be driven (*a*) hydraulically, (*b*) by engine (flexible drive), (*c*) electrically. In modern installations they are removed from the engine when practical, the purpose being to keep the fuel in the relatively lengthy lines under pressure, to minimize vapor lock. They generally incorporate a relief valve and a vent to the ram air-intake scoop, or the external supercharger. This vent maintains a constant discharge pressure by a balancing action through a diaphragm. Some types are of variable speed, and some types are of variable volume.

Fuel systems other than gravity incorporate a hand fuel pump (wobble pump) to furnish fuel prior to starting the engine and as a safety precaution in the event of failure of

the engine-driven fuel pump. They usually employ a relief valve to prevent excessive pressures at the carburetor.

Primers.—Primers are utilized to provide an excess of fuel for starting purposes. The priming pump is a piston-type, hand-operated pump, located in the cockpit. Primers are generally pulled out slowly to allow filling, then vigorously pushed in to aid in atomizing the priming charge. They must be shut off when not in use.

Vapor Eliminator.—Some systems include a vapor eliminator. This is usually installed in the fuel pressure line at the carburetor, or in some cases is built into the carburetor, the function being to rid the system of fuel vapors.

Pressure Signals.—Fuel pressure warning signals are in use to notify the operator when a fuel tank is running low. They operate when the fuel pressure drops below a predetermined pressure at the carburetor.

CARBURETION

Carburetion Principles.—A carburetor is a device to mix fuel with air in the proper proportions. To accomplish this, it is necessary to measure the amount of air fed to the engine and to meter the fuel in the correct proportions necessary to proper engine operation.

The fuel-air ratio requirements vary according to engine speed and load; therefore, the carburetor must be capable of determining and meeting these conditions. Carburetion is dependent on atmospheric pressure and behavior; therefore, a modern airplane carburetor must be sensitive in proportioning the fuel to the air as conditions arise. Useful mixture ratios vary between 11 to 1 to 16 to 1 (air-fuel ratios), all proportions on a basis of weight. They are generally designated as decimal fractions. Best power ratio is about 0.080. As a fraction $.080 = {}^{83}\!/_{1000} = {}^{1}\!/_{12}$. Various ratios are expressed as 0.087 rich best power and 0.075 lean best power, etc.

The process of converting a liquid (gasoline) to a gaseous state (fuel-air mixture) is accomplished in three steps—metering, atomization, and vaporization. The induction system assists in this function. The supercharger also contributes to even distribution and vaporization.

Function of the Carburetor.—All carburetors serve the same function, to meter the fuel and air according to engine requirements. Excessively rich mixtures are accompanied by loss of power, black smoke, and carbon monoxide. Very lean mixtures will cause loss of power and overheating. Lean mixtures are often accompanied by backfiring.

Each carburetor incorporates a venturi. The function of a venturi is to accelerate the air flow, thereby creating a pressure drop. The differential in air pressure at the entrance to the venturi and the throat (restriction) is the criterion for measuring the requirements of the engine (fuel and air).

Carburetors consist of various devices to regulate the fuel flow. In general, there are five means of accomplishing this: (*a*) an idling system to function at idling and low speeds, (*b*) an accelerating system to take care of rapid throttle opening and consequently increased engine requirements, (*c*) a main discharge system for cruising and full-power operation, (*d*) a mixture control for altitude adjustment, (*e*) an economizer system for full-power (rich-mixture) and lean operation when desired. Most modern carburetors are automatic or semiautomatic in their operation. This is necessary, to relieve the pilot of correcting for various settings in addition to his many other duties. The trend on most accessories is to make them fully automatic in operation. This eliminates the possibility of human error and is much more accurate and sensitive in regulating changes.

Types of Carburetors.—Carburetors are of three general types—the variable-venturi diaphragm type, the pressure-injection type, and the float type.

Variable-venturi Diaphragm Type.—These carburetors are designed to minimize icing troubles and to provide better

fuel flow in rough air and rapid maneuvers. The fuel is discharged past the throttle and abrupt changes are eliminated. Thus, these types are practically nonicing. Synchronized throttle venturis operate in conjunction with a metering pin to provide proper mixture ratio at various degrees of throttle opening. A diaphragm mechanism replaces the conventional float chamber, supplying proper fuel flow under all conditions. The fuel is fed under pressure of 6 to 7 lb. per sq. in.

The velocity of the air entering the engine creates a suction on the fuel-discharge system, which is fed from the diaphragm fuel chamber through a metering channel and passes the metering pin and its seat. The fuel-metering characteristics are controlled by the cam profile on the metering pin, which operates in conjunction with the variable venturis.

These carburetors employ a power compensator, which serves the same function as the economizer on float-type carburetors. They use an accelerator pump of the vacuum-diaphragm type. The action of this pump is automatic. Other features include idle cutoff, automatic mixture control, vapor eliminators, and power-mixture valves to prevent the use of lean mixtures at high-power output, which could cause serious damage to the engine.

Pressure-injection Type.—Carburetors of this type supply fuel in correct proportions under pressure from the time the fuel leaves the fuel pump until it is discharged into the engine. Nonicing, accurate metering, freedom from fuel boiling and vapor lock, and complete maneuverability are some of the advantages claimed.

The fuel is fed at approximately 12 to 15 lb. pressure, directly to the supercharger adapter. Better atomization and more even characteristic result. The fuel flow is regulated by differential pressure created by the venturi action. The suction at the throat of the boost venturi is the measure of the mass of air flow. It is directed to a diaphragm regulator unit, to control the fuel flow across fixed jets in the fuel-control unit.

The fuel-control unit, in turn, feeds the fuel-discharge nozzle. This type of carburetor may be termed an *air-metering pressure carburetor.* Impact tubes measure scoop pressure, the boost venturi measures suction velocities. The pressure differential between the two is directed against an air diaphragm, which, in turn, actuates the fuel-control system. Various other units, such as mixture controls, idle cutoff, economizer, etc., complete the carburetor.

Float Type.—Carburetors of the float type are still extensively used. The fuel is drawn into the air stream through a discharge nozzle by the pressure drop caused by the venturi action. A constant level of fuel is maintained in the float chamber by the action of the float mechanism. The amount of air admitted to the engine is controlled by the throttle butterfly valve. This valve is located on the engine side of the carburetor. Within the range of the air velocities of the venturi tube, the fuel flow and the air flow remain fairly constant in proportion to the suction created. To regulate the fuel flow through the discharge nozzle, a metering jet is provided, to meter the fuel more accurately.

The action of the venturi is to speed up the air flow, thereby causing a pressure drop. The pressure drop in the venturi causes fuel to flow into the air stream because the atmospheric pressure is higher than the venturi pressure. This pressure drop also aids in vaporization of the fuel. In the rapid vaporization of large quantities of fuel, an appreciable temperature drop takes place. This principle is used in mechanical refrigeration. The fuel absorbs heat as it vaporizes. This process is known as *latent heat of vaporization.* To convert a liquid (fuel) to a gas (fuel-air mixture), the fuel is atomized, or broken down into small particles. As fuel and air become intimately mixed, the state is called *vaporization.* To aid in atomizing the fuel, and to reduce the amount of suction required to lift the fuel from the discharge nozzle, an air bleed is incorporated. The air-bleed jet also assists in providing uniform mixtures.

The *accelerating system* is to provide an oversupply of fuel during the acceleration period. If the throttle is opened rapidly, a temporary leanness occurs. The accelerating system functions to prevent this "flat spot," or lean-mixture condition, during this period. Generally the carburetor is equipped with an accelerating pump, connected to the throttle shaft, to supplement the fuel supply to the main discharge nozzle, in order to furnish a rich mixture on the sudden opening of the throttle.

The *idling system* is used to supply the engine with fuel when the throttle is closed. It is practically independent of the main discharge system and functions at idling and low speeds only. As the throttle is opened, the main discharge system functions and the delivery from the idling system ceases.

The *main discharge system* supplies the engine with its cruising and full-power requirements. It includes jets or drill restrictions to meter fuel flow. Jet sizes are given in twist-drill numbers. The higher the number, the smaller the jet size. The discharge nozzle serves to atomize the fuel and the air bleed assists in this function.

The *mixture-control system* serves to regulate the fuel flow at altitude. As has been previously mentioned, the rate of air and fuel mixed by the carburetor is proportional to suction. As the engine attains altitude, the volume is proportional, but the density of the air decreases. The fuel flow remains fairly constant. However, the air, while occupying the same space, does not have the proportional weight. The result is that the fuel-air ratio becomes richer because fewer pounds of air are being consumed. The rate of enrichment is inversely proportional to the square root of change in air density. To maintain a constant fuel-air ratio at various altitudes, the mixture control is employed. This is accomplished by reducing the suction on a metering system (back-suction type) or restricting the fuel flow in the main discharge system (needle-and-seat type). Automatic mixture controls are very effective for this purpose.

The automatic mixture control consists of a metallic bellows that is responsive to temperature and density changes. Reduced pressure at altitude causes the bellows to expand, moving a mixtures control valve near its seat, thereby maintaining the proper fuel-air proportions. It is a sealed unit filled with nitrogen and an inert oil to dampen vibration. Back-suction mixture control also incorporates an idle cutoff feature. When placed in the idle cutoff position, it stops the engine rather abruptly by causing a very low pressure to exist in the float chamber. This feature is valuable in preventing preignition and afterfiring, particularly after the engine has been run or taxied on the ground for an appreciable length of time.

The *economizer system* derives its name from the economy of operation resulting from its use. It is actually an enriching device for higher power operation. At cruising speeds it leans out the mixture and, as the throttle is opened for higher power output, it allows more fuel to flow, providing richer mixtures. It consists of a needle-and-seat assembly linked to the throttle shaft and set to function at a predetermined throttle opening. It is set during assembly and is not considered as a carburetor adjustment.

Float-type carburetor fuel levels are set by adding or subtracting washers under the float-needle seat. Dirt and corrosion are still the main difficulties in carburetor operation. However, a modern carburetor is a precision instrument and the manufacturer's specifications and procedures should always be followed.

MULTIPLE-CHOICE QUESTIONS*

1. The heat value per pound of gasoline is about

a. 20,000 B.t.u.
b. 18,000 B.t.u.
c. 25,000 B.t.u.
d. 12,050 B.t.u.

* A key to the answers is given on p. 139.

2. The principal elements in aviation gasoline are
a. carbon and nitrogen
b. carbon and oxygen
c. carbon and hydrogen
d. oxygen and hydrogen

3. An engine loads up at all speeds except full-throttle and cruising speeds. The probable cause is
a. air leaks in idling tubes
b. improper setting of mixture control
c. faulty setting of high-speed jets
d. partially open economizer valve
e. clogged air bleed

4. Fuel flow to the main nozzle on a diaphragm-type carburetor is governed by
a. the venturi
b. a set orifice that is controlled by the compression ratio of the engine
c. a needle valve that is linked to the throttle so that when the throttle is moved the needle is moved on or off its seat
d. the vacuumatic pressure induced by the action of the piston on the intake stroke and boosted by the venturi
e. pressure of the float on the fluid in the float chamber

5. The principal elements in air are
a. oxygen and carbon monoxide
b. nitrogen and oxygen
c. carbon dioxide and oxygen

6. The principal products of combustion are
a. nitrogen and carbon dioxide
b. oxygen and carbon monoxide
c. carbon dioxide and water

7. The initial boiling point of aviation gasoline is approximately
a. 105°F.
b. 212°F.
c. 325°F.
d. 475°F.

8. If a float needle or seat is grooved, you should

a. turn the needle down on a bench lathe and grind the seat with a coarse compound

b. replace the entire assembly

c. replace the needle and grind the seat

d. apply a coarse compound to the needle only and grind the needle into the seat until all grooves have disappeared

e. turn down the needle and replace the seat

9. Detonation occurs

a. at high altitudes

b. only when idling

c. if ignition timing is late

d. after ignition

e. before ignition

10. Too low a boiling point of fuel will cause

a. difficult starting

b. vapor lock

c. overheating

d. excessive fuel consumption

11. The best economy-mixture ratio for an aviation engine is approximately

a. 15 parts of air to 1 part of fuel by weight

b. 13 parts of air to 1 part of fuel by weight

c. 18 parts of air to 1 part of fuel by volume

12. The part of the carburetor that increases the action of the air is called

a. the economizer

b. the pump jet

c. the throat

d. the air scoop

e. the venturi

13. The purpose of an air bleed is

a. to lean the mixture

b. to purge air bubbles that become trapped in the line

c. to maintain the required mixture, regardless of the speed of the engine

d. to vaporize the fuel

e. to remove water that might accumulate in the fuel

14. Volatility of a fuel is

a. its tendency to vaporize

b. its tendency to resist flowing

c. the antiknock quality of the fuel

d. the tendency to burn fast

15. The gasoline recommended for use in aviation engines is

a. cracked

b. blended

c. casing-head

d. straight-run

16. Operating an engine on too lean a mixture will

a. cause the engine to overheat

b. economize on fuel

c. cause excessive fuel consumption

d. cause the engine to run too cool

17. If an attempt is made at utilizing full power of a supercharged engine at altitudes not high enough to warrant it, the result would probably be

a. an appreciable loss of power

b. rough and irregular operation of the engine

c. overheating of the cylinders

d. master-rod failure

e. excessive fuel pressure

18. If an engine exhausts black smoke, it means that

a. the mixture in the carburetor is lean

b. the mixture in the carburetor is rich

c. oil is passing the piston rings and burning in the combustion chamber

d. there is an excessive air leak in the bleeds

e. there is a leak in the exhaust stack

19. The low-pressure area at the discharge nozzle is created by

a. the opening of the throttle

b. the air flowing through the venturi

c. the back-suction mixture control
d. the needle-valve type of mixture control
e. the air horn

20. The accelerating pump is found
a. in the pilot's cockpit
b. in the passenger's cabin
c. on the accessory drive of an engine
d. in the carburetor
e. in the venturi tube

21. The main advantage of gasoline as aircraft fuel is
a. its low specific gravity
b. its heat energy
c. the ability of gasoline to maintain pressure under varying atmospheric pressures
d. its high hydrocarbon content
e. its low hydrocarbon content

22. The function of the throttle valve in a carburetor is to
a. create a suction at the discharge nozzle
b. control the horsepower and speed of the engine
c. control the flow of fuel to the carburetor
d. operate the economizer
e. control the mixture ratio

23. The main metering jet controls fuel flow
a. at idling speeds
b. when the engine is quickly accelerated
c. at cruising and full-throttle operation
d. at wide-open throttle only

24. A distinguishing characteristic of detonation is
a. an appreciable rise in oil pressure
b. exhausting blue smoke
c. exhausting black smoke
d. an appreciable rise in the cylinder-head temperature
e. an appreciable drop in the oil pressure

25. The altitude or mixture control in a carburetor
a. prevents a rich mixture at high speeds

b. causes a rich mixture at high speeds to prevent overheating
c. is a means to prevent a rich mixture at high altitude and economize while cruising
d. increases pressure in the venturi
e. is to accelerate engine quickly

26. The float mechanism in a carburetor is used to
a. prevent fuel from backing up in the lines
b. control the amount of fuel forced through the discharge nozzle
c. maintain the proper level of fuel in carburetor
d. maintain an even pressure on the fuel line
e. control the engine horsepower and speed

27. If a float needle does not seat properly, the result will be
a. the engine will starve at high altitudes
b. the carburetor will flood at high altitudes
c. the primer will fail to function
d. an appreciable loss of power throughout the entire range of operation
e. the carburetor will drip at the lower speeds

28. The well surrounding the discharge nozzle on a multijet carburetor is used to
a. afford quicker acceleration
b. cool the nozzle and prevent vapor locking
c. prevent surging in the nozzle
d. aid in bleeding
e. drain possible leakage from the nozzle

29. When an engine is idling with throttle closed,
a. the idling jet is also closed
b. the accelerating jet is pumping
c. the mixture control is open wide
d. the main jet is idle
e. the economizer is open halfway

30. The purpose of a manifold pressure gauge is
a. to indicate the pressure in the manifold above atmospheric pressure

b. to indicate pressure in the manifold at high altitudes only
c. to indicate the rate of flow of the charge as it leaves the manifold
d. to indicate the rate of flow of the air entering the manifold
e. to indicate the difference in manifold and atmospheric pressures

31. The function of a wobble pump is to
a. pump fuel to the engine for starting and in emergency when the engine pump fails
b. keep an even pressure on the fuel to the carburetor
c. give the pilot a means of controlling the fuel pressure to the carburetor
d. prime the engine for starting
e. by-pass fuel around the engine pump

32. Flexible connections are used in fuel lines to
a. prevent metal fatigue and breaking of the tubing
b. prevent vibration of the tubing
c. provide a means for easy assembly and disassembly
d. eliminate the necessity for annealing tubing
e. save cost in building and maintaining the airplane

33. Metal liners are used in hose connections to
a. provide a means for bonding
b. make a rigid connection
c. prevent foreign substances from getting into the carburetor
d. align the fuel lines
e. aid in assembly

34. The admission of ice through a carburetor of a supercharged engine will cause
a. the engine to skip and miss until the ice is removed or melted
b. an intake valve to break
c. intake valve seats to pit
d. serious damage to the supercharger impeller

35. Baffles are used in fuel tanks to
a. prevent surging of fuel and strengthen tank

b. allow higher pressures to be used
c. prevent collapsing during rapid change in pressure, as in a dive
d. help prevent leakage at rivets and welds
e. cool fuel to reduce vaporization

36. Metal liners are not always necessary when installing bases made of some kinds of synthetic rubber because of
a. the extreme flexibility of synthetic rubber
b. the fact that some kinds of synthetic rubber are impervious to gasoline and oil
c. the rigidity of synthetic rubber
d. the elastic qualities of synthetic rubber
e. the resilience of synthetic rubber

37. Octane rating is
a. the adaptability of the gasoline to an engine of a specific horsepower rating
b. the value of the gasoline in terms of its ability to resist detonation
c. the rating of the gasoline in terms of thousands of feet of altitude per specified horsepower
d. the rating of the gasoline in terms of its benzal content
e. the rating of the gasoline in terms of specific gravity

38. The best economy-mixture ratio for an aviation engine is approximately
a. 15 parts of air to 1 part of fuel, by weight
b. 13 parts of air to 1 part of fuel, by weight
c. 15 parts of air to 1 part of fuel, by volume
d. 18 parts of air to 1 part of fuel, by weight
e. 1 part of fuel to 15 parts of oxygen, by weight

39. Too lean a mixture may cause
a. low manifold pressure
b. backfiring through the carburetor
c. low float level
d. carbon formation in the combustion chamber
e. fouling of spark plugs

40. Operating on too rich a mixture may cause

a. excessive fuel pressure
b. high manifold pressures
c. too high a float level
d. low manifold pressures
e. dilution of the oil

41. Icing in the carburetor is most likely to occur at

a. the throttle valve
b. the venturi
c. the discharge nozzle
d. the main air bleed
e. the main metering jet

42. A fuel tank should be kept full while the airplane is stored in a hangar so as

a. properly to balance the weight on the tires
b. to equalize stress on the landing gear
c. to prevent the tank's drying and destroying the inside finish
d. to prevent dirt from accumulating on the surface of the fluid
e. to prevent condensation in the tank

43. If difficulty is encountered when attempting to adjust a carburetor for a rich mixture, the cause may be

a. the octane rating of the gas is too high
b. the octane rating of the gas is too low
c. a clogged air bleed
d. improper setting of the economizer valve
e. a broken spring on the accelerator pump

44. A supercharger is used to

a. increase the fuel content of the mixture in the carburetor when the throttle is in the wide-open position, because of the small orifices through which the fuel is conducted
b. keep the battery charged to its capacity under all conditions of operation
c. enable the engine to attain its full rated horsepower at all altitudes

prevent a drop in fuel pressure when the airplane reaches the higher altitudes

increase the motivating pressure of the mixture when atmospheric pressure is below a pressure necessary to maintain a required power value

45. The back-suction type of mixture control

a. restricts the main fuel passage
b. by-passes air around the venturi
c. causes low pressure in the float chamber, restricting fuel flow
d. causes a greater pressure difference between the float chamber and the discharge nozzle, causing a rich mixture at high altitudes
e. allows more air to enter to the venturi tube

46. A needle-valve mixture control at sea level is normally

a. on its seat
b. off its seat
c. in full lean position
d. in an intermediate position
e. controlled by the throttle control

47. A needle-type valve economizer

a. is adjusted after the carburetor is installed on the engine so that it begins to open at 200 r.p.m. before wide-open throttle

is adjustable by the pilot

c. is adjusted after starting the engine to give best mixture
d. is set in the shops to open with the throttle valve at a certain angle
e. is not adjustable

48. A wobble pump is used to

a. provide a safety supply if the mechanical pump should cease to function

transfer a supply of gasoline to the supply tank from an outside source

maintain a steady flow of fuel when the altitude of the plane is disturbed abruptly

d. aid the mechanical pump to take off when the maximum supply is needed
e. economize on fuel

49. The float level in a Stromberg carburetor
a. is adjusted by bending the float arm
b. is adjusted by raising or lowering the float fulcrum
c. is adjusted by increasing or decreasing the fuel pressure
d. is adjusted by adjusting the valve seat by adding or removing spacers
e. is set at the factory and is not adjustable

50. The venturi in a carburetor is used to
a. direct the flow of the mixture to the intake manifold
b. afford a screen for the back-suction type of mixture control
c. maintain constant octane rating
d. create a suction so as to increase the rate of flow of the mixture
e. maintain correct the fuel-air ratio

51. A diffuser is used to
a. distribute the mixture evenly among the cylinders
b. separate particles of dirt from the mixture
c. manually control the fuel-air ratio at varying altitudes
d. direct the air flow from the supercharger to the carburetor

52. A clutch is used in the impeller drive-gear train to
a. control the speed of the impeller
b. prevent too high a manifold pressure from being reached
c. prevent the impeller from flying apart as a result of centrifugal force
d. protect the shafts and gears from sudden shocks, which might break them
e. control the manifold pressure

53. The mixture control known as the back-suction type is used to
a. restrict the flow of fuel at idling speed to prevent "loading up" and flooding
b. permit free passage of fuel to the intake manifold

c. reduce the atmospheric pressure acting on the fuel in the float chamber to the existing pressure at varying altitudes
d. mix properly the fuel charge without using the air flow through the venturi
e. increase the flow of fuel at idling speed

54. The manifold pressure can be exceeded by
a. having the clutch too tight
b. having too high a gear ratio
c. opening the throttle too wide
d. using too large an impeller
e. overheating the air intake

55. The flow of air through a carburetor is regulated by
a. the venturi diameter
b. the pressure of the supercharger impeller
c. a throttle valve
d. an air jet
e. the economizer valve

56. A disadvantage of a supercharged engine in comparison with a nonsupercharged engine is that it
a. weighs more per horsepower
b. makes it more difficult to control the mixture ratio
c. requires greater skill on the part of the pilot and maintenance crew to operate
d. requires a lower octane rating fuel
e. can maintain rated horsepower at high altitudes

57. A faulty accelerating pump will cause
a. the engine to run irregularly
b. difficulty in obtaining an idling adjustment
c. the carburetor to flood when the engine is allowed to idle for an appreciable length of time
d. the main metering jet to clog
e. difficulty in reaching maximum acceleration

58. The type of supercharger most commonly used on aviation engines is
a. vane type

b. Roots blower type
c. centrifugal type
d. gear type
e. hydraulic type

59. If the supercharger in an engine should fail, it would cause
a. a richer mixture
b. a leaner mixture
c. loss of power at high speeds
d. detonation in the cylinders
e. preignition

60. Fuel flows from the idling discharge nozzle
a. at idling speed
b. at idling and low speeds
c. at low and medium speeds
d. some, at all speeds
e. when starting only

61. The carburetor float level is adjusted by
a. an adjusting screw fitted with a lock screw
b. slightly bending the float arm
c. adding weights to the float
d. lowering the level of the fuel in the float chamber
e. placing shims under the needle-valve seat

62. The reason for annealing fuel lines that are made of copper is
a. to make them pliable for easy handling
b. to prevent kinking on installation
c. to prevent crystallization
d. to prevent vapor locking
e. to facilitate lagging

63. The so-called "hot spot" is a heater used
a. to heat the pilot's cockpit
b. to heat the fuel mixture before it enters the intake manifold
c. to heat the oil reservoir to enable the oil to flow freely when cold

d. to heat the rocker boxes to prevent oil congealing
e. to heat the venturi

64. The main mixture control, while the airplane is on the ground, should be set
a. at full-rich position
b. at full-lean position
c. at best power rich setting
d. at best power lean setting
e. near the halfway position between rich and lean

65. The result of having too high an air temperature in the carburetor will be
a. burned intake valves
b. a compaction of mixture at the main nozzle walls, causing a back pressure
c. an overheated engine
d. an appreciable drop in oil pressure
e. inability of the engine to attain its full rated horsepower

66. The purpose of a main air-bleed jet is
a. to supply a suitable vent for the flow of fuel at high altitudes
b. to purge the fuel system of air bubbles
c. to aid in the converting of the fuel from a liquid to a gas
d. to keep the fuel in the float chamber at a constant level
e. to prevent an accumulation of dirt in the main jet

67. Partially filled fuel tanks on an airplane that has been left idle for an appreciable length of time should be
a. emptied, cleaned, and refilled with fresh fuel
b. sealed tight against dirt, water, and other foreign matter
c. heated, to insure against a retarded flow of fuel when ready for take-off
d. drained to fuel, and the fuel should be strained through a chamois and replaced
e. drained and washed out with a 20 per cent solution of sulphuric acid and washed with kerosene and warm water

68. The idling-mixture control should be set
a. full rich for cold operations

b. full lean
c. as rich as possible with smooth operation with the engine warm
d. as rich as possible with smooth operation with the engine cold
e. halfway between rich and lean

69. Idling speed should be adjusted
a. in the shop before installation
b. after engine warm-up
c. in flight
d. after starting, but before warm-up
e. before each flight

70. When making connections with a flex base, a metal liner is used to
a. prevent friction on the rubber base
b. prevent the base connections from separating
c. prevent the fluid from coming in contact with rubber and destroying it
d. maintain rigidity throughout the line
e. relieve tensile stress on the rubber

71. The pressure relief valve is used to
a. by-pass fuel around the pump to the carburetor
b. prevent high pressure at the discharge nozzle
c. maintain a constant pressure at the fuel inlet to the carburetor
d. prevent vaporization of fuel at high altitudes
e. maintain a constant pressure at the discharge nozzle

72. Failure of a supercharged engine to develop rated power may be caused by
a. overheated spark plugs
b. an improperly atomized mixture at higher altitudes resulting from a defective back-suction type of mixture control
c. a slipping clutch on the supercharger, causing a lack of air pressure

d. broken impeller blades on the impeller
e. overheated cylinder heads

73. If you encounter difficulty in adjusting a supercharged engine for idling, the cause may be
a. the economizer valve is stuck closed
b. a worn throttle shaft
c. a worn piston or the accelerating pump
d. improper fuel-air ratio
e. the main metering jet is clogged

74. The purpose of the by-pass valve and line is
a. to relieve high pressure in the lines
b. to by-pass fuel back to the tank
c. to allow fuel to pass around the engine pump when the hand pump is used
d. to maintain a constant pressure at the fuel inlet to the carburetor
e. to control the amount of fuel flowing to the discharge nozzle

75. The fuel pump is frequently located at some distance from the engine because
a. it can draw the fuel from the tank more easily
b. it reduces the danger of vapor locks in the fuel lines
c. when mounted nearer the tank, it can build up higher pressures
d. weight is reduced because return lines are shorter
e. the fire hazard is not so great with the pump farther from the engine

76. The wobble pump, when connected,
a. must be in series with the engine pump
b. must be parallel to the engine pump
c. may be either in series or parallel
d. is entirely separate from the main fuel system
e. must be only between tanks

77. When the float level is too high, the result will probably be
a. an excessively rich mixture if the engine is supercharged

b. that an excessive suction will be necessary to draw enough mixture into the intake manifold
c. a low level in the discharge jet

78. The level of the fuel in both the main and idling passages is controlled by
a. the level in the accelerating cylinder
b. the diameter of the venturi at the throat
c. the capacity of the supercharger
d. the r.p.m. of the engine
e. the level of the fuel in the float chamber

79. A signal light in a fuel system is to
a. indicate to the pilot when the fuel pressure is too high
b. show the pilot when the pressure relief valve is working
c. indicate when the fuel pressure is too low
d. warn the pilot when the by-pass valve does not work
e. show how much fuel flows to the carburetor

80. Too low a boiling point of the gasoline may cause
a. vapor lock
b. overheating of the engine
c. difficult starting
d. carburetor icing
e. excessive fuel consumption

81. The purpose of a supercharger is to
a. decrease the fuel consumption of the engine
b. allow a higher grade of fuel to be used
c. allow a lower grade of fuel to be used
d. increase the horsepower of the engine at high altitudes
e. control the horsepower and speed of the engine

82. The metering jets controlling the fuel flow at full throttle and at cruising speed are
a. controlled in flight
b. of the fixed-orifice type and require no adjusting
c. syncronized by orifice gauges
d. of identical orifice diameters
e. made of tungsten steel

83. The diffuser plates and vanes are to
a. distribute the fuel more evenly to the cylinders
b. maintain the proper clearance between the impeller and diffuser sections
c. maintain the proper mixture ratio
d. convert the energy represented by velocity to energy represented by pressure
e. remove any foreign matter from the mixture

84. Too high a manifold pressure will
a. blow out the gaskets in the manifold
b. cause detonation in the cylinders
c. place excessive stresses on the impeller
d. cause a rich mixture
e. cause a lean mixture

85. The formation of ice in a carburetor may cause
a. the engine to run roughly or fail completely
b. the supercharger to break down
c. the venturi throat to diminish in size
d. the main metering jet to clog
e. the accelerating pump to become inoperative

86. The fuel pressure at the carburetor should be
a. checked before each flight
b. checked at periodic inspections
c. sufficient to maintain a normal level of fuel in the float chamber
d. sufficient to maintain pressure at the main metering jet
e. sufficient to maintain pressure at idling speeds

87. The economizer is used to
a. save fuel at full power
b. save fuel at cruising speed without sacrificing power, and overheating at wide-open throttle
c. help maintain a constant mixture at all altitudes
d. help maintain a constant mixture at all speeds
e. economize on fuel at idling speeds

88. A vapor lock in a fuel line may cause
a. overheating of the fuel

b. overheating of the engine
c. failure of the engine at high speeds
d. too high a float level
e. regular missing on one or more cylinders

89. If the accelerating pump in a carburetor fails, the effect will probably be
a. too rich a mixture at high speeds
b. too lean a mixture at low speeds
c. too lean a mixture at high speeds
d. poor acceleration of the engine only
e. low pressures in the float chamber

90. Too high a fuel pressure may cause
a. high manifold pressure
b. high pressure in the float chamber
c. carbon formation in the cylinders
d. blue smoke from the exhaust
e. overheating of the engine

91. The float level is usually measured
a. by the mark on the outside of the float chamber housing
b. by a bubble gauge
c. from the system level to the parting surface
d. from the parting surface to the top of the main metering jet
e. from the parting surface to the level of the idling jet

92. The chemically correct fuel-air ratio is
a. 7 lb. of air to 1 lb. of fuel
b. 11 lb. of air to 1 lb. of fuel
c. 17 lb. of air to 1 lb. of fuel
d. 15 lb. of air to 1 lb. of fuel

93. The purpose of the idle cutoff is to
a. by-pass fuel around the venturi and the throttle valve
b. lean the mixture with altitude
c. regulate the idle r.p.m.
d. stop the engine by stopping fuel flow

94. The purpose of a fuel analyzer is to
a. analyze the fuel for carbon content

b. analyze the fuel for oxygen content
c. indicate the amount of carbon in the unburned state
d. provide a means of determining the fuel-air ratio of the mixture
e. provide a means of determining the moisture content of the fuel mixture

95. The purpose of flexible connections on fuel lines when the connection is made between the engine and the airplane is
a. to afford flexibility to conform with the rubber mountings of the engine
b. to prevent the copper lines from overheating because of close approximation with the engine
c. to provide a means of rapid detachment when changing engines
d. to reduce vibratory action on the lines
e. to prevent electrical contact between the engine and the fire wall

96. The reason for not locating fuel lines too close to the exhaust system is
a. to prevent expanding the fuel as a result of heat transfer through the lines
b. to prevent a fire hazard
c. to prevent an annealing act on the fuel lines
d. to prevent the danger of fire resulting from a leaky carburetor and the backfiring of the engine
e. to prevent vapor locking

97. The function of a metering pin on a variable-venturi carburetor is to
a. enrich the mixture at full throttle
b. regulate the fuel flow to the discharge nozzle
c. provide an increase in fuel for quick acceleration
d. provide a means of stopping the engine

98. The accelerating pump on a variable-venturi carburetor is actuated by
a. the throttled arm
b. venturi suction

c. providing an increase in fuel for quick acceleration
d. providing a means of stopping the engine

99. The economizer in a carburetor is used to
a. supply an extra amount of fuel when the necessity for it arises
b. restrict the rate of flow of fuel when idling or at lower speeds
c. regulate the flow of mixture at the main jet
d. add air to the mixture when the throttle reaches a certain point in its travel
e. meter out fuel as it is consumed, with a thought to economy

100. The variable-venturi carburetor accelerating pump consists of
a. check valve, spray nozzle, diaphragms, and springs
b. two check valves, spray nozzle, diaphragms, and springs
c. sleeve, piston, valve, and spring
d. check valve, bellows, diaphragms, springs, and poppet valve

101. Supercharging an engine means
a. revolving an engine impeller more than 6 to 1
b. decreasing manifold pressure to save fuel
c. increasing manifold pressure above the atmospheric pressure
d. bringing manifold pressure just below the atmospheric pressure

102. The normal operating pressure on the variable-venturi carburetor is approximately
a. 6 to 7 lb.
b. 14 to 16 lb.
c. 7 to 9 lb.
d. 4 to 5 lb.

103. The principal advantage of the Bendix Stromberg pressure carburetor is that
a. it can fly inverted
b. it is lighter in weight

c. it requires simple maintenance
d. it will not ice up

104. Atmospheric pressure at 20,000 ft. is approximately
a. 14.5 Hg
b. 14.7 lb. per sq. in.
c. 20 Hg
d. 20 lb. per sq. in.

105. A fuel pressure gauge is used to
a. measure the difference in pressure between carburetor fuel-air intakes
b. measure the quantity of fuel in the tank
c. indicate fuel flow in the fuel system
d. indicate fuel pressure at the carburetor
e. maintain a constant pressure in the system

106. The pressure relief valve of a Pesco fuel pump is vented to the carburetor air intake
a. because the pump is designed to provide a greater quantity of fuel than is necessary
b. when the manifold pressure is higher than the atmospheric pressure
c. when an internal gear supercharger is used
d. when the carburetor air-intake pressure is above normal atmospheric pressure
e. it is vented to the atmosphere at all times

107. The pour point is
a. the temperature at which rain begins to fall
b. the point at which fuel begins to flow from the discharge nozzle
c. the lowest temperature at which oil will flow
d. the S.A.E. viscosity number of an oil

108. The flash point pertains to
a. the lowest temperature at which the fumes from oil will burn
b. the lowest temperature of an oil
c. the combustion in the cylinder
d. vapor lock in a fuel line

109. Viscosity is
a. the antiknock quality of a gasoline
b. the tendency of a liquid to vaporize
c. the body of an oil or its resistance to flow
d. the resistance of an oil to changes of temperature

110. The viscosity index is
a. the viscosity of an oil taken at different temperatures up to 210°
b. the number of impurities in the oil
c. the maximum pressure and temperature without detonation
d. the number of tubes on an injector carburetor

111. The fractionating process is
a. the mixing of isooctane and normal heptane
b. the breaking up of crude oil into its various products
c. the mixing of gasoline, tetraethyl lead, and isooctane to produce high-test gasoline
d. the separating of the different octane fuels

112. The economizer of float-type carburetors is usually operated
a. by differential pressure
b. automatically
c. by separate manual control
d. actuated by the throttle

113. The purpose of the accelerating pump is
a. to save fuel at wide-open throttle
b. to enrich the mixture at wide-open throttle
c. to aid in increasing the r.p.m. rapidly
d. it has no effect on the mixture

114. Relative humidity is
a. difference in atmospheric pressure
b. the relation between the amount of water vapor in the air at sea level and at high altitudes
c. the tendency of a carburetor to ice in warm weather
d. the amount of water vapor in the air compared to the amount of water vapor in the air when the air is saturated

115. The dew point is

a. water vapor held in suspension

b. the temperature at which the air can no longer hold its water vapor in suspension

c. the lifting condensation level of a column of air

d. the condensing of water vapor at a high temperature

116. What is the purpose of the two-speed supercharger?

a. to maintain manifold pressure

b. to increase the manifold pressure

c. to supply more fuel for higher altitudes

d. to supercharge two engines

117. What kind of material is used on the induction-pipe packing gland?

a. cork

b. rubber

c. lead-graphite packing

d. asbestos

118. What is the purpose of the slip joints on exhaust manifolds?

a. to permit inspections

b. to permit easier installation

c. to aid in keeping manifolds cool

d. to allow for expansion

119. A diffuser plate is used to

a. force the charge of fuel and air into the cylinder

b. change the high velocity of the charge to pressure

c. speed up the velocity of the charge

d. increase the manifold pressure

120. The function of the thermostatic valve on the oil temperature regulator is to

a. force oil to go around the outside when it is closed

b. force oil to go through the tubes when it is closed

c. by-pass the oil when the valve is open

d. by-pass the oil when the valve is closed

121. What is the purpose of the clutch or flexible drive on the impeller gears?

a. so that the impeller will be speeded up
b. to relieve stress on gears
c. to prevent excessive speed of the impeller
d. to prevent the impeller's going backward in case of backfire

122. Where is the hot spot located?
a. between air intake and carburetor
b. between carburetor and blower
c. between blower and cylinder
d. between blower and induction pipes

123. Under what condition will the waste gate of an exhaust-driven supercharger be completely closed?
a. at sea level
b. at high altitudes
c. at low altitudes
d. for take-off only

124. Is it possible to use more than one supercharger on the same engine?
a. it would not be practical
b. they would absorb too much horsepower
c. they are used on all high-altitude engines
d. they will weigh too much

125. What type of supercharger shows greatest efficiency at very high altitude?
a. Roots blower
b. exhaust turboblower
c. internal gear-driven type
d. two-speed blower

ESSAY-TYPE QUESTIONS*

126. Describe the procedure for clearing an engine that has been overprimed, or overloaded.

127. Name the principal functions of oil in an engine.

128. How would you decrease the r.p.m. of an engine that is idling too fast?

* Answers are given on p. 139.

129. Name three factors that would cause detonation.

130. What is the function of a carburetor? Explain.

131. From what should all aircraft fuels be free?

132. What is the position of the throttles when an aircraft engine is being started?

133. What is meant by the rate of combustion?

134. What does each of the following indicate?

a. bluish-white flame direct from the exhaust stack

b. short red flame from the exhaust stack

c. thick black billowy smoke, often followed by fire, from stacks

d. very long whitish-orange flame

e. a short, snappy bluish-purple flame at an engine speed of about 2,600 r.p.m.

135. Does the hand pump (or, as it is commonly called, the *wobble* pump) discharge fuel when the handle is operated in both directions?

136. What results are probable if an engine is operated on a lean mixture at full throttle?

137. What are the three general types of carburetors in use on aircraft engines?

138. What name is generally applied to the carburetor device that provides a rich mixture at high-power output?

139. Name two carburetor adjustments that are effective at idling speeds.

140. When checking a turbosupercharger system with the engine operating, what instrument reading is most efficient?

141. Why are adjustable throttle stops installed on some types of throttle controls?

142. What is the function of the diffuser plates, or vanes?

143. Which is the most conspicuous control in any combined engine control unit, and why?

144. How are geared internal impellers driven, and why?

145. What is the proper procedure for stopping an engine equipped with a Stromberg injection-type carburetor?

146. (*a*) What is meant by a two-speed supercharger? (*b*) What is meant by a two-stage supercharger?

147. What procedure is recommended if an engine does not start after five or six revolutions?

148. For engine operation what is the maximum safe carburetor air temperature?

149. Name several possible reasons why a Stromberg pressure-type carburetor will not cut off.

150. How is the turbosupercharger impeller speed regulated?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 113

1. *a*	2. *c*	3. *e*	4. *d*	5. *b*	6. *c*
7. *a*	8. *b*	9. *d*	10. *b*	11. *a*	12. *e*
13. *d*	14. *a*	15. *a*	16. *a*	17. *c*	18. *b*
19. *b*	20. *d*	21. *b*	22. *b*	23. *c*	24. *d*
25. *c*	26. *c*	27. *e*	28. *a*	29. *d*	30. *e*
31. *a*	32. *a*	33. *c*	34. *d*	35. *a*	36. *b*
37. *b*	38. *a*	39. *b*	40. *e*	41. *a*	42. *e*
43. *d*	44. *e*	45. *c*	46. *b*	47. *d*	48. *a*
49. *d*	50. *d*	51. *a*	52. *d*	53. *c*	54. *c*
55. *c*	56. *c*	57. *e*	58. *c*	59. *c*	60. *b*
61. *e*	62. *c*	63. *b*	64. *a*	65. *e*	66. *c*
67. *a*	68. *c*	69. *b*	70. *c*	71. *c*	72. *c*
73. *b*	74. *c*	75. *b*	76. *c*	77. *a*	78. *e*
79. *c*	80. *a*	81. *d*	82. *b*	83. *d*	84. *b*
85. *a*	86. *a*	87. *b*	88. *c*	89. *d*	90. *b*
91. *c*	92. *d*	93. *d*	94. *d*	95. *d*	96. *e*
97. *b*	98. *b*	99. *a*	100. *b*	101. *c*	102. *a*
103. *d*	104. *a*	105. *d*	106. *c*	107. *c*	108. *a*
109. *c*	110. *a*	111. *b*	112. *d*	113. *c*	114. *d*
115. *b*	116. *a*	117. *b*	118. *d*	119. *b*	120. *b*
121. *b*	122. *b*	123. *b*	124. *c*	125. *b*	

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 137

126. The procedure for clearing an engine that has been overprimed or overloaded is as follows: First, *make sure that the ignition switch is off.* If the carburetor is equipped with an idle cutoff, place it in the idle-cutoff position, open the throttle, and turn the engine over several revolutions by hand or by means of the starter.

127. The principal functions of oil in an engine are to lubricate the engine parts, to help cool the engine, to seal compression, to scavenge.

128. To decrease the r.p.m. of an engine that is idling too fast, back off on the idling screw at the throttle stop on the carburetor. This idling screw controls the amount of opening of the butterfly in the carburetor. Screwing in would increase the r.p.m. and backing off would decrease the r.p.m.

129. Three factors that would cause detonation are too lean a mixture, too low an octane fuel, and exceeding the maximum ground r.p.m. or manifold pressure.

130. The function of a carburetor is to aid vaporization, to meter the gasoline with the air entering the engine, and to maintain the proper fuel-air ratio under all conditions of operation.

131. Aircraft fuels should be free from water, sulphur, corrosive compounds, and gum-forming tendencies.

132. The throttle should be opened slightly, to get between about 800 to 1,000 r.p.m.

133. During normal combustion, the fuel-air mixture burns evenly over a period of time. This is known as the *rate of combustion.*

134. The exhaust flames listed in the question indicate

a. Incomplete combustion caused by incomplete burning of fuel and air mixture in the combustion chamber. A drop in r.p.m. may be noticed, also.

b. An oil flame, average length 4 to 7 in., usually accompanied by a whitish, billowy smoke. This flame may be noticed in one set of stacks and be entirely lacking in another.

c. An overloaded condition, noticed only when starting and often followed by fire from the stacks. This type is caused by overpriming and constitutes a dangerous fire hazard.

d. Defective spark plugs. This indicates detonation appearing intermittently and is inclined to be spasmodic or explosive in appearance. It usually appears from one or more stacks.

e. Correct mixture. This flame may be very hard to distinguish at times, depending upon the lighting conditions.

135. Yes, the wobble pump, or hand pump, will discharge fuel when the handle is operated in both directions.

136. The probable results would be overheating, high head temperatures, and detonation.

137. Three general types of carburetors on aircraft engines are the float type, the Bendix Stromberg pressure type, and the Holly type.

138. The economizer is the device that provides a rich mixture at high-power output. This may be known also as the *power-enrichment valve.*

139. The two carburetor adjustments that are effective at idling speeds are the idling-mixture control and the idling screw—the idling-mixture control for idling mixtures, and the idling screw for r.p.m.

140. A manifold pressure gauge is most sufficient. It must always be remembered that the maximum ground manifold pressure should never be exceeded.

141. Adjustable throttle stops are incorporated in some throttle controls to prevent the operator from exceeding maximum ground r.p.m. and manifold pressure.

142. The function of the diffuser plates, or vanes, is to convert the high velocity of the mixture to pressure and also to distribute the mixture evenly to all cylinders.

143. The most conspicuous control is the throttle, because it is the most widely used. This control is usually marked with the letter T.

144. Geared internal impellers are driven through hydraulic friction, or spring couplings, to absorb shock caused by abrupt changes in engine r.p.m.

145. The proper procedure for stopping an engine equipped with an idle cutoff (Stromberg injection-type carburetor) is as follows: Move the mixture control to idle-cutoff position with the engine running at about 800 r.p.m. and, at the same time, open the throttle. Turn off the ignition *after* the engine stops.

146. Some superchargers have a means for changing the speed from a low to a high ratio. These are known as *two-speed* superchargers. When an exhaust-driven supercharger is used in conjunction with an internal blower, it is called a *two-stage* supercharger.

147. The procedure recommended is to make sure that the ignition switch is off, open the throttle, and turn the engine over several revolutions by hand or by means of the starter. NOTE: If the engine is equipped with an idle cutoff, be sure that the idle cutoff is in the *off* position.

148. For safe engine operation the maximum carburetor air temperature should not exceed 41°C. or 105°F.

149. Several probable reasons are that the poppet valves are stuck open, the regulator fill valve is stuck open, the mixture-control disk is not seating properly, the discharge nozzle is not seating, and the accelerator pump is not seating.

150. The turbosupercharger impeller speed is regulated by incorporation of a waste gate in the turbosupercharger unit. This unit can be controlled either automatically or manually.

CHAPTER V

IGNITION AND ELECTRICAL SYSTEMS

IGNITION

To provide a spark or an electric flame to ignite the compressed mixture in the cylinder, magnetos are commonly employed. Some engines use battery ignition, and some a combination of battery and magneto ignition. In either case, the net result is to ignite the charge at the proper time in the cylinder.

Magnetos.—The principal advantage of a magneto is that it is a self-contained unit, not dependent upon any external electrical source such as a battery. Another advantage is that the intensity of its spark increases with engine speed. Magnetos are to create, intensify, and distribute electrical currents. Essentially, they are generators with a high-voltage output.

Construction.—A modern magneto is constructed with a stationary coil and a rotating magnet. Breaker points, distributor, condensers, pole shoes, etc., are some of the other component parts. The coil consists of a primary and a secondary winding. By the rotation of the permanent magnet, a voltage is produced in the primary field when the breaker points are closed. The breaker points are timed to open or collapse the primary circuit at the point when its current values are strongest. The sudden collapse or breaking of the primary current produces a high voltage in the secondary winding of the coil. The distributor is timed to collect the secondary current at its peak and deliver it to the spark plug at the proper instant. A condenser is connected across the breaker points to assist in collapsing the primary field by reducing arcing.

A switch is provided to ground out the primary circuit when the magneto is no longer required.

Timing.—Magnetos are timed internally by proper meshing of the gears and are timed externally by properly coupling them to the engine at the required number of degrees before top center on the compression stroke of No. 1 cylinder. Magnetos fire consecutively, while engines fire according to their firing order. Therefore, while the No. 1 lead from the magneto always goes to No. 1 cylinder, the No. 2 lead will always go to the second cylinder in the firing order, No. 3 lead to the third cylinder to fire, etc.

Booster Coil.—Most magnetos require a booster coil as an aid in starting. The coming-in speed, or point at which the magneto will fire consistently, is approximately 100 r.p.m. Most starters will not crank the engine so fast. The function of the booster coil is to supply a shower of sparks to the plugs until the magneto fires properly. The booster is generally connected to the starter switch. After the engine starts, both the booster coil and the starter are no longer required. The booster coil fires through a trailing segment or finger on the distributor arm, which automatically retards the spark, to prevent engine kickback, as that can cause serious damage.

Ignition System.—A complete ignition system consists of two magnetos, radio-shielded harness, booster coil, spark plugs, and switches.

The number of lobes on a magneto determines the number of sparks in each revolution of the magneto. The number of sparks required by the engine is determined by the number of its cylinders. A formula for determining magneto speeds is

$$\frac{\text{number of cylinders}}{\text{number of lobes} \times 2}$$

For example:

$$\frac{12 \text{ cylinders}}{4 \text{ lobes} \times 2} = \frac{12}{8} = 1\frac{1}{2} \text{ times engine speed}$$

Dual Ignition.—To burn the charge more quickly—thereby minimizing detonation—and to increase power output, two spark plugs and two complete ignition systems are provided. This also provides an additional safety feature. On radial engines standard practice is to use the right-hand magneto for the front set of plugs and the left-hand magneto for the rear.

Dual ignition may be set to operate at the same instant (*synchronized* ignition) or at slightly different intervals (*staggered* ignition). Breaker points may be of the pivot type or the spring type, called *pivotless*.

The reason for staggered ignition is the location of the exhaust spark plug. This plug located on the hottest side of the cylinder necessitates an advance in ignition timing resulting from the slower rate of burning of the expanded and diluted mixture at this point in the cylinder. In staggered ignition, the exhaust plugs always fire first.

ELECTRICAL SYSTEMS

Starters.—The function of the starter is to crank the engine. Modern engines use direct-electric cranking or electric-inertia starters. The inertia starter consists of a motor, a clutch to absorb overloads, and dogs or engaging devices. A flywheel is incorporated to store up energy. The motor spins the flywheel to a speed of approximately 12,000 r.p.m. When the engaging device is energized through a solenoid switch, the dogs mesh and the kinetic energy stored in the flywheel is expended in cranking the engine.

Cartridge-type starters also have been successfully employed. They utilize the expansion of a slow-burning powder charge to crank the engine.

Generators.—Generators furnish current for radio, batteries, lighting, instruments, etc. They convert mechanical energy to electrical energy. Electric motors convert electrical energy to mechanical energy. When constant-output genera-

tors are used, the current is controlled by a voltage regulator, which serves to adjust the generator output to the airplane's requirements. Some direct-electric starters actuate a hydraulic gear-type pump for feathering and unfeathering hydraulic propellers. These motors are series wound for maximum torque (twist) for cranking.

Batteries.—Batteries store chemical energy. This energy is converted to electrical energy when a circuit is completed. A storage battery is composed of a group of cells connected in series. These batteries are known as the *lead-acid* type. Each cell or unit consists of lead plates immersed in an electrolyte (sulphuric acid solution). The plates are prevented from contacting by separators. The constant charging and discharging of the battery causes chemical changes in the lead plates and the solution. The condition of charge of the battery may be determined by the use of a hydrometer. The specific gravity of a fully charged battery is about 1.300, whereas the discharge battery will read about 1.100. Distilled water is used to replace any of the solution that evaporates. Vents are used to allow gases to escape. Care should be taken not to spill the electrolyte, as the acid solution is highly corrosive. Open flame should be kept from the batteries when they are being charged, because of the danger of an explosion, inasmuch as hydrogen gas is being given off. Batteries should always be securely clamped when installed in an airplane. Proper maintenance of modern electrical equipment is a specialty in itself. The mechanic should never attempt electrical jobs unless he is fully competent in repairs of this nature.

Relays.—Relays permit the controlling of heavy currents by means of small wires and switches. Solenoid relays are used in aircraft, to allow heavy wires to be run direct to the starter, etc. This reduces weight and permits remote control of various electrical devices. A solenoid switch consists of a coil with a movable core. When the coil is energized, the core is attracted to the coil. Suitable contacts are closed by

the action of the solenoid, thereby allowing a high-amperage current to flow direct to dynamotors, starters, etc.

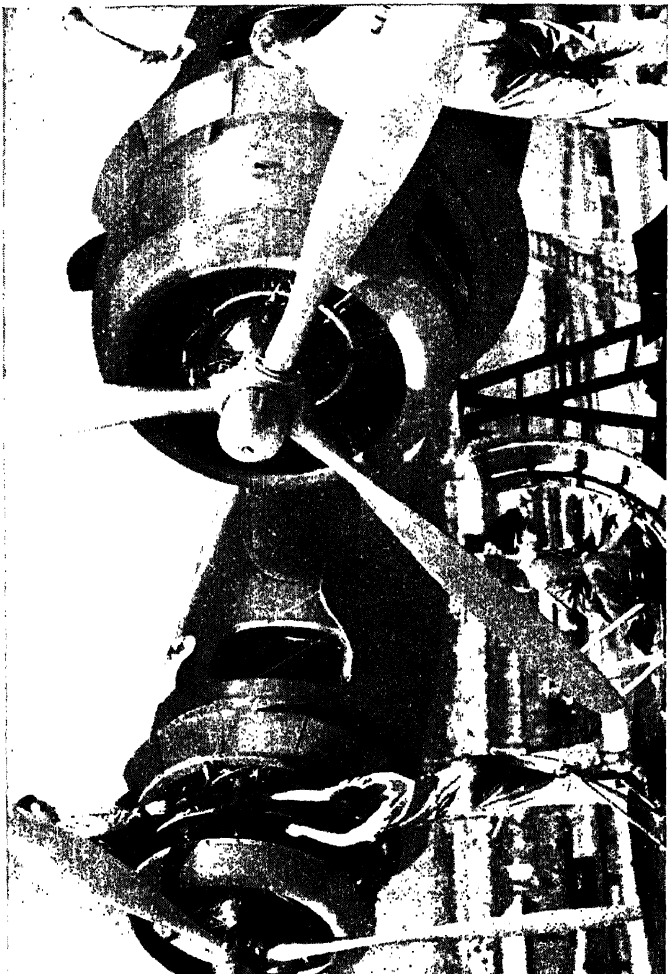
Shielding and bonding are to minimize electrical interference in radio reception. The magnetos, especially, set up high-frequency currents. Radiations of the currents are readily picked up by the plane's receiver. By the grounding of these emanations proper reception is assured. Shielding may be flexible metal braid or nonflexible coverings called *conduits*. Bonding is the electrical connection of various sections, shielding, etc., to the plane structure. Bonding braid must be short and securely grounded to prevent different voltages from setting up in various parts of the aircraft.

High-tension wires that supply the current from the magnetos to the spark plugs, along with their shielding, are commonly called the *ignition harness*. This assembly of wires, conduits, and shielding can be of several types. Generally, the high-tension wire is of flexible-metal core construction, with a covering of rubber or synthetic rubber.

Spark plugs are of mica or ceramic construction. Their function is to provide a gap within the cylinder for the spark to jump, thereby igniting the compressed charge. Spark-plug temperatures are rather high. High-compression engines require the use of cold plugs to conduct excess heat rapidly, whereas lower compression engines employ hot plugs to prevent fouling. The proper heat range of the plugs is extremely important. Manufacturers' data should always be followed.

Solid copper gaskets are used as an aid in heat dissipation. Spark plugs should never be tightened excessively, as they may seize or distort the plug shell. Spark-plug and ignition harness are still a constant source of trouble in aircraft engines. Developments in this field, however, are rapidly taking place.

Compensating magnetos are used on late-model radial engines. They function to supply the spark to the cylinders at the same number of degrees before top center in each individual cylinder. Owing to the design of the articulating-



Engine mechanics putting the finishing touches on a large four-engine airplane.

rod construction, top dead center of each piston is not exactly the same number of degrees of crankshaft rotation. This is due to the geometry of the master and articulated rods.

This type of magneto has a breaker cam with individual lobes for each cylinder. The cam speed is one-half crankshaft speed. The lobes are precision ground to compensate for the unequal top dead center intervals of radial-type engines. The unequal intervals of lobes result in even firing in the cylinders. The E gap on these magnetos varies slightly, but the net result is more even engine performance and higher power output.

The E gap on all magnetos is the number of degrees that the rotating magnet has passed its neutral position before the points begin to open. This position corresponds to the instant when the highest voltage will be produced in the secondary. To time compensating magnetos, it is necessary to locate the master or No. 1 lobe and time this lobe to the No. 1 cylinder. This will automatically ensure all the cylinders' firing evenly in their proper sequence.

These magnetos actually fire at slightly odd intervals, but they are known as even-firing magnetos.

MULTIPLE-CHOICE QUESTIONS*

1. Why is it necessary to check the valve timing on radial engines?

a. to see that the valves open and close
b. to see that the engine was assembled correctly
c. to determine the valve lift
d. to determine the valve clearance

2. What is the contact-point clearance on magnetos with pivot-type breaker points?

a. 1/8 in.
b. 0.002″
c. 0.012″
d. no set clearance

* A key to the answers is given on p. 165.

3. At what points is valve timing checked on radial engines?

a. intake to open, exhaust to close
b. intake to close, exhaust to open
c. intake to open, exhaust to open
d. intake to close, exhaust to close

4. What is the allowable error in ignition timing?

a. 0.060″
b. no allowance
c. 2 deg.
d. 5 deg.

5. What is the purpose of timing clearance?

a. to have valve open slightly early
b. to set breaker-point gap on the magneto contacts
c. to have valves close a little late
d. to allow for cylinder expansion

6. In what position are magnetos timed?

a. advanced position
b. retarded position
c. halfway between advanced and retarded positions
d. with the breaker assembly turned all the way in the direction of rotation

7. The valve timing on an engine must be done before the magneto timing, because

a. valve adjustment cannot be made with the magneto in place
b. adjusting the magneto breaker points changes valve timing
c. the compression stroke cannot be determined until valves are timed
d. with the spark plugs in place, the engine cannot be easily rotated

8. The supplementary timing marks on a magneto show that the

a. breaker points are just opening
b. distributor is in position to fire No. 1 cylinder

c. direction of rotation of the distributor gear is clockwise
d. use of timing lights is unnecessary

9. What is the allowable error in valve timing?
a. 0.060″
b. no allowance
c. 2 deg.
d. 5 deg.

10. What is meant by staggered ignition?
a. when two magnetos are used
b. when each of the two sparks occurs at a different time
c. when a double magneto is used
d. when the spark plugs are not exactly opposite each other

11. Cleaning spark plugs is accomplished by
a. disassembly and cleaning with gasoline and a wire brush
b. shortening electrodes with a 6V or a 12V battery
c. use of sand-blasting equipment
d. cleaning electrodes with crocus cloth
e. dipping plugs in an acid solution

12. Stranded ignition wire is used on aircraft because
a. it will carry more amperage
b. it is not so susceptible to breakage
c. it can be more easily soldered
d. it is more economical
e. it provides a hotter ignition spot

13. Ignition shielding is necessary to
a. protect aircraft in severe electrical storms
b. eliminate radio disturbance
c. provide a return ground for ignition system
d. protect wiring from oil and corrosion
e. provide a means of mounting ignition harness to the engine

14. The purpose of a condenser in aircraft ignition is to
a. absorb self-induced shocks or current flowing in the primary circuit
b. increase current flow at breaker points

c. eliminate arcing at contact points, which would interfere with radio reception
d. protect the secondary circuit in case of broken high-tension wire
e. short the primary current to the ground

15. The battery ignition switch in the *off* position
a. shorts the primary circuit to the ground
b. disconnects the battery from the ignition coil
c. shorts the secondary circuit
d. opens the secondary circuit
e. shorts the condenser

16. The primary winding on an ignition coil is connected to
a. ground and the secondary winding
b. the battery and the insulated breaker contact point
c. ground and the insulated spark-plug electrode
d. the battery and the switch
e. ground and the condenser

17. Fuses in electrical circuits are used to
a. shunt excessive current flow to ground
b. open an overloaded circuit
c. tell the pilot when the battery is fully charged
d. absorb excessive flow of current caused by self-inductance
e. put resistance in a circuit

18. In battery ignition systems a broken cam-follower fiber on the breaker arm will cause
a. arcing at contact points
b. an open primary circuit
c. a closed primary circuit
d. the engine to be out of time
e. an open secondary circuit

19. The current in the primary circuit should reach its maximum valve in a scintilla magneto when
a. breaker points just close
b. the rotating magnet wing is directly under a pole shoe
c. when the breaker points begin to open

d. when the distributor rotor is bearing on the distributor block segment
e. when the condenser becomes fully discharged

20. A shorted condenser will cause
a. excessive secondary current in the ignition coil
b. uneven firing of cylinders on that system
c. overheated spark plugs
d. an open primary circuit
e. complete ignition failure

21. Magnetos are generally overhauled
a. every 25 hr.
b. every 120 hr.
c. when the spark plugs are changed
d. at engine overhaul

22. The number of times a four-pole rotating magnet reverses direction of magnet flux in one revolution of magneto is
a. six
b. eight
c. nine
d. four
e. two

23. Intensity of current in the secondary circuit depends upon
a. spark-plug condition and gap
b. the speed at which the magnet field around the primary collapses
c. the speed of the rotating magnet
d. ignition timing and compression of the engine
e. the size of wire used for spark-plug wiring to the distributor

24. The primary bridge on a scintilla magneto affords a means of
a. supplying a booster current
b. grounding insulated breaker contacts
c. escape for excessive current produced by the magneto

d. connecting the primary winding to the secondary winding
e. grounding the condenser

25. Breaker points become pitted when
a. spring tension on them is weakened
b. oil and dirt form on their surface
c. their clearance is excessive
d. condenser capacity is low
e. primary current flow is weak

26. The booster segment always trails the secondary-service segment on the distributor rotor to
a. give an advanced spark for starting
b. give a retarded spark
c. furnish a hotter spark
d. ensure maximum contact with the distributor block segment
e. offer less resistance in the booster circuit

27. A magneto with two cam lobes coupled to a four-cylinder in-line engine would turn at
a. one-quarter times crankshaft speed
b. twice crankshaft speed
c. four times crankshaft speed
d. once crankshaft speed
e. $1\frac{1}{4}$ times crankshaft speed

28. Magneto ignition has an advantage over battery ignition in that it
a. is more suitable for starting purposes
b. is better suited for low-speed operation
c. is more economical
d. has better running qualities at high speeds
e. is less susceptible to wear

29. The condenser in a scintilla magneto is connected from
a. the movable breaker to ground
b. primary to secondary windings
c. core of coil to stationary breaker
d. core of coil to ground
e. secondary winding to primary bridge

30. A safety gap is sometimes used to
a. eliminate arcing at breaker points
b. intensify secondary current
c. protect spark plugs and ignition wiring
d. provide a return ground when the secondary circuit is open
e. open the primary circuit in case of a crash

31. Advanced ignition timing is used to
a. ensure better spark distribution for starting
b. allow more time for the mixture in the cylinder to burn
c. allow firing of the charge after it is compressed
d. supply a later spark in the cylinder at high speeds
e. preheat an incoming fuel charge

32. Ignition occurs in the cylinder when
a. the piston is coming up on exhaust
b. the piston is coming up and both valves are closed
c. the intake valve has just opened and the piston is moving down
d. the piston is a few degrees ATDC.
e. the piston is approaching TDC and the intake valve is opening

33. The safety gap is connected
a. in series with the secondary circuit
b. between secondary and primary
c. in parallel with secondary
d. across breaker points
e. between distributor, rotor, and coil assembly

34. A booster magneto is necessary on large engines because
a. they require a hotter spark than do the smaller engines
b. they cannot operate with the service magneto only and require additional current in the ignition system at high speeds
c. a large engine cannot be turned over fast enough to have the service magneto furnish a good spark for starting
d. secondary current in a service magneto must be stepped up

e. they keep the engine running in case of a magneto's cutting out

35. The primary winding on an ignition coil consists of

a. many turns of rather heavy wire

b. comparatively few turns of heavy wire

c. many turns of very fine wires

d. a few turns of fine wire

e. many turns of heavily insulated wire

36. In wiring a magneto to an engine over 100 hp., wire the numbers on distributor blocks

a. to the same numbered cylinder on the engine

b. all the even numbers to all the odd-numbered cylinders and vice versa

c. to the cylinders in relation to their firing order

d. to half of the cylinders and other magnetos to the remaining cylinders

e. to the same numbered cylinder front spark plug and other magneto, or rear spark plug

37. A solenoid consists of

a. a hollow coil wound with uninsulated wire

b. a coil of wire with a soft iron core

c. a hollow cylinder wrapped with insulated wire and having a movable core

d. a permanent magnet on which are wound coils of heavy wire

e. two electro magnetos whose fields oppose each other

38. A voltmeter is always connected in a circuit

a. in series

b. between battery and load

c. in parallel with breaker points

d. across the battery terminals

e. between ignition coil and ignitor

39. A fuse in a circuit should always be connected

a. in series as near as possible to the source of supply

b. in parallel with the battery

c. between ammeter and switch

d. from battery positive direct to ground
e. across contact points in the ignitor

40. The unit used for measuring electromotive force is
a. watt
b. ampere
c. ohm
d. volt
e. columb

41. Electricity is caused to flow by
a. a difference of potential in a conductor
b. joining two unlike metals together
c. connecting two pieces of wire of like material but of different resistance together
d. connecting a wire to the side of a source of electrical energy
e. grounding one end of a conductor

42. An insulator is made of any material that
a. has a low resistance to electrical current flow
b. does not allow the passage of any electrical current through it
c. allows very little current to flow
d. is porous
e. has a high melting point

43. A battery generates electrical energy as a result of its
a. chemical action
b. plate capacity
c. size
d. internal temperature
e. state of charge

44. Staggered ignition timing is sometimes used because
a. the intake charge should be ignited sooner
b. it offers more flexibility in engine operation
c. the mixture near the exhaust valve burns slowly
d. cylinders on the engine do not reach TDC in an even number of degrees

e. a more pronounced spark can be obtained at the spark plug

45. An induction coil is used to

a. induce a current in a conductor

b. induce a current of different intensity in another circuit

c. induce an a.c. current in a line

d. absorb an excessive current flow

e. prevent mutual induction

46. The firing order of an engine is

a. the order in which cylinders are numbered on the crankcase

b. the time interval between ignition sparks

c. the sequence or occurrence of the intake valve's closing when the engine is turned in the direction of rotation

d. the order in which wires from the magneto distributor are connected to the engine spark plugs

e. relative to the number of degrees of advance required for ignition timing

47. Compensated magnetos are used

a. on inverted engines

b. in live engines

c. on V-type engines

d. on opposed-type engines

e. on radial engines

48. A master switch is used in aircraft to

a. disconnect all electrical equipment from the battery

b. shut off either one or both ignition systems

c. ground both magnetos

d. start the engine

e. complete the circuit from the source of ignition current to the spark plugs

49. Dual ignition systems should be used on engines with

a. 40-hp. output or over

b. four cylinders or more

c. 100-hp. output or over

d. high-rated speeds over 2,250
e. low-rated speeds under 2,250

50. Fuses used in aircraft electrical circuits must be
a. of lower capacity than the battery
b. easily changed in flight by the pilot or a member of the crew
c. installed in parallel with the battery terminals
d. capable of carrying any amount of current the battery can produce
e. able to melt readily in case of fire

51. To find TDC of a piston one should use a
a. manufacturer's manual and a flashlight
b. timing disk
c. pointer and a master spline
d. TC indicator
e. flashlight in spark-plug holes

52. The cause of a magneto's misfiring at high speed is a
a. wide spark-plug gap
b. weak coil
c. cracked block
d. faulty breaker spring
e. weak-impulse coupling spring

53. The gap in a spark plug is set according to
a. the type of magneto used
b. the horsepower of the engine
c. the compression ratio of the engine
d. the volumetric efficiency of the engine
e. the age of the engine in actual hours

54. The firing order on a 12-cylinder engine is
a. 1L, 6R, 5L, 2R, 3L, 4R, 6L, 1R, 2L, 5R, 4L, 3R
b. 1L, 2R, 6R, 3L, 1R, 5R, 4L, 3R, 4R, 2L, 3R, 5L
c. 2R, 1L, 6R, 3L, 1R, 5R, 4L, 3R, 2L, 4R, 5L, 3R
d. 1L, 6R, 3L, 2R, 1R, 5R, 4L, 3R, 5L, 3R, 4R, 2L
e. 1L, 6R, 2R, 1R, 3L, 5R, 4L, 3R, 5L, 3R, 4R, 2L

55. The firing order on a nine-cylinder radial engine is
a. 1, 3, 5, 7, 9, 4, 2, 6, 8

b. 1, 3, 5, 9, 7, 4, 2, 6, 8
c. 1, 3, 5, 7, 9, 2, 4, 6, 8
d. 1, 3, 5, 7, 9, 2, 6, 4, 8
e. 1, 5, 3, 7, 9, 2, 4, 6, 8

56. The firing order on a conventional 14-cylinder, double-row radial engine is
a. 1, 10, 5, 14, 9, 4, 13, 8, 3, 12, 7, 2, 6, 11
b. 1, 10, 5, 14, 9, 4, 8, 13, 3, 12, 7, 2, 6, 11
c. 1, 5, 10, 14, 9, 8, 4, 3, 13, 12, 7, 2, 11, 6
d. 1, 10, 5, 14, 9, 4, 13, 8, 3, 12, 7, 2, 11, 6
e. 1, 10, 5, 14, 4, 9, 13, 8, 3, 12, 7, 2, 6, 11

57. The firing order on a seven-cylinder radial engine is
a. 2, 4, 6, 7, 1, 3, 5
b. 2, 4, 6, 1, 3, 5, 7
c. 2, 4, 6, 1, 5, 3, 7
d. 2, 4, 6, 1, 3, 7, 5
e. 2, 4, 6, 5, 7, 3, 1

58. A magneto is timed by
a. adjusting the points to the right clearance
b. timing the magneto to the engine
c. properly meshing the magneto gears
d. lining up the large gear with the timing marks on the case
e. setting the mark on the gear with the two marks on the case

59. The firing order of an engine is governed by
a. the number of cylinders to be fired
b. the model of magneto
c. the type of fuel used
d. the type of the spark plugs
e. the conditions under which the engine is to be flown

60. The cause of point pitting is
a. a weak coil
b. too strong a coil
c. a weak condenser
d. too strong a condenser
e. too wide a gap

61. The compression ratio of an engine governs
a. the type of fuel necessary
b. the strength of the magneto condenser
c. the type of spark plug necessary
d. the firing order of an engine
e. the type of oil used

62. To maintain magnetism in a set of magnets that have been removed from a magneto for any appreciable length of time
a. wrap the magnets in tissue paper to keep them clean
b. cover the magnets with a heavy grease to protect them from rust
c. place them on a wooden service to protect them from damage
d. place a soft-iron connector across the poles to retain the magnetism
e. place a brass connector across the poles to retain the magnetism

63. V-type engine cylinders are numbered
a. usually from the gear end
b. usually from the propeller end
c. from the gear end on the right bank
d. from the propeller end on the left bank
e. from the center back, then forward

64. Magneto breaker points should
a. close just BTC
b. open just BTC
c. open just ABC on the compression stroke
d. open just BTC on the compression stroke
e. open just at TC

65. An impulse is used on a magneto to
a. make a safer coupling
b. count the power impulses
c. facilitate quicker starting
d. produce synchronization
e. advance the spark at starting

66. On the twin-row radial engine
a. the odd-numbered cylinders are in the rear and the even-numbered cylinders are in the front
b. the even-numbered cylinders are in the rear and the odd-numbered cylinders are in the front
c. the numbers are staggered
d. half the even-numbered cylinders are in the front row and the other half are in the rear row
e. 1, 3, 5, 7, 9 of the odd-numbered cylinders are in the front row and the rest of the odd-numbered cylinders are in the rear row

67. Low-pressure engines have
a. dual ignition
b. cold spark plugs
c. superchargers
d. hot spark plugs
e. a dual magneto in a single unit

68. An engine will run rough, skip, and miss if
a. the supercharger shaft is worn
b. the high-speed jet is clogged
c. the pump jet is leaking
d. the accelerating spring is broken
e. the spark-plug gaps are too wide

69. Complete combustion is obtained by
a. the intensity of the spark at the spark plug
b. the exhaust valve's opening at the proper time
c. the magneto points' opening just after TDC on the compression stroke
d. the magneto points' opening just BTC on the exhaust stroke
e. the magneto points' opening just BTC on the compression stroke

70. The primary circuit is open on a battery system when
a. the engine is idling
b. the engine is running at cruising speed
c. the switch is off

d. the engine is running at full throttle
e. the breaker points are open

71. To help prevent radio interference,
a. ground all electrical wires in the ignition system
b. ground all spark plugs and switches
c. bond all moving parts of the magnetos
d. shield all spark-plug wires
e. shield the magnetos

72. The primary circuit is connected
a. in parallel with the breaker points
b. in series with the breaker points
c. in parallel with the switch
d. in series with the switch
e. in series with the rotor

73. The secondary circuit is protected against shorts or open circuits by
a. grounding the secondary windings
b. shielding the primary circuit
c. an adequate insulator pencil
d. a safety fuse
e. a safety gap

74. The magnetic field in a primary circuit will
a. cause pitting of points if too strong
b. cause misfiring at cruising speed if too weak
c. induce a current in the secondary circuit by reversal of its field
d. induce a current in the secondary circuit by preventing a reversal in the secondary field
e. burn out cold running spark plugs if too strong

75. One cause of difficulty in starting an engine would be
a. a faulty adjustment of the breaker points
b. slightly pitted breaker points
c. too strong a primary circuit
d. an overloaded condenser
e. spark plugs too hot

ESSAY-TYPE QUESTIONS*

76. Does a wire of greater cross-sectional area have more or less resistance than a wire of less cross-sectional area?

77. While a storage battery is discharging, current flows in one direction. When it is being charged, is the current forced through it in the same or the opposite direction?

78. In what form is the active chemical of a dry cell?

79. What is the specific gravity of a fully charged storage battery?

80. In timing a scintilla magneto internally, what timing marks are necessary?

81. What is used to protect aircraft structure near the battery against corrosion?

82. What is used to remove corrosion from battery terminals?

83. What is the maximum gap allowed before a spark plug must be reset?

84. What would cause continual burning of the breaker points of the magneto?

85. Why do some airplanes have a caution sign not to turn the propeller when the magneto ground wires are disconnected at the fire wall.

86. The lead marked *H* in the distributor is for what? The lead marked *P* in the distributor is for what?

87. The lead from No. 5 cylinder, front plug, connects to what number in the distributor of what magneto in a nine-cylinder engine?

88. Besides a voltage regulator's being out of adjustment, what else could cause a low reading on the voltmeter?

89. What is likely to occur if an engine is operated at high speed on only one magneto?

90. What will cause spark-plug gaps continually to open and become greater?

* Answers are given on p. 166.

91. What effect would burned or pitted magneto breaker points have on engine operation on that magneto?

92. What effect would a short-circuited condenser have on a magneto?

93. What procedure would be used to disengage a stuck starter dog on an engine?

94. On shielded batteries, in what order should the wing nut, lock washer, and plain washer be installed. Why are they installed this way?

95. Why is magneto ignition superior to battery ignition on aircraft engines?

96. What may be used in aircraft electrical systems to take the place of fuses? Name two.

97. What is the purpose of a condenser in a high-tension magneto?

98. Describe the neutral position of the rotating magnet in an aircraft magneto?

99. Why is it necessary on a twin-engine installation to have both generators develop the same voltage? How is this done?

100. If you noticed voltage on the voltmeter but no amperage on the ampmeter, what would be the likely trouble?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 149

1. *b*	2. *c*	3. *a*	4. *c*	5. *d*	6. *a*
7. *c*	8. *b*	9. *d*	10. *b*	11. *d*	12. *b*
13. *b*	14. *a*	15. *b*	16. *b*	17. *b*	18. *c*
19. *c*	20. *e*	21. *d*	22. *d*	23. *b*	24. *b*
25. *d*	26. *b*	27. *d*	28. *d*	29. *a*	30. *d*
31. *b*	32. *b*	33. *a*	34. *c*	35. *a*	36. *c*
37. *c*	38. *d*	39. *a*	40. *d*	41. *a*	42. *b*
43. *a*	44. *c*	45. *b*	46. *c*	47. *e*	48. *a*
49. *c*	50. *b*	51. *c*	52. *d*	53. *c*	54. *a*
55. *e*	56. *d*	57. *b*	58. *c*	59. *a*	60. *c*
61. *a*	62. *d*	63. *a*	64. *d*	65. *c*	66. *a*
67. *d*	68. *e*	69. *e*	70. *c*	71. *d*	72. *b*
73. *e*	74. *c*	75. *a*			

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 164

76. A wire of greater cross-sectional area has less resistance.

77. While a storage battery is being charged, the current is sent back in the opposite direction.

78. The form of the active chemical in a dry-cell battery is in *paste* form.

79. The specific gravity of a fully charged storage battery (12 volt) is between 1,275 and 1,300.

80. It is necessary, when timing a scintilia magneto internally, to mesh the punch marks on the gears.

81. To protect aircraft structure near the battery against corrosion it is necessary to use an acid-resisting paint.

82. To remove corrosion from battery terminals, use a solution of ammonia or baking soda mixed with water.

83. The maximum gap allowed before a spark plug must be reset is 0.020 in.

84. Continual burning of the breaker points of a magneto could be caused by weak breaker springs, dirt or oil on the points, weak or defective condensers.

85. Some airplanes have a caution sign not to turn the propeller when the magneto ground wires are disconnected at the fire wall because, if the propeller were turned by hand when these wires were disconnected, the magnetos would put out a spark, which might cause the engine to start and injure someone.

86. The lead marked *H* in the distributor is for the high-tension wire from the booster. The lead marked *P* in the distributor is the primary ground wire from the magneto to the magneto switch.

87. The lead from No. 5 cylinder, front plug, connects to No. 3 right magneto.

88. Besides a voltage regulator's being out of adjustment, some of the other causes for a low reading on the voltmeter would be dirty or pitted voltage-regulator contacts, loose or dirty high-resistance connections, worn brushes, dirty or

rough commutator, low brush spring tension, shorted armature or other trouble in the generator.

89. The cause that is most likely to occur to an engine operated at high speed on only one magneto is detonation. It could lead into mechanical failure.

90. One cause for spark plugs to open continually and become greater is continual overloading of the engine by the operator.

91. The effect burned or pitted magneto points would have on engine operation would be intermittent misfiring on all cylinders at all speeds, when operated on that magneto.

92. The effect of a short-circuited condenser would be a dead magneto.

93. The proper procedure for disengaging a stuck starter dog on an engine would be to make sure that the ignition switch is in the off position and then turn the engine in the direction of rotation by hand.

94. The order in which the wing nut, lock washer, and plain washer should be installed on a shielded battery is as follows: lock washer, plain washer, wing nut. The reason they are installed in this manner is to have the plain washer next to the wing nut, to protect the lead plating from being mutilated, thereby reducing the possibility of corrosion of the wing nut.

95. The advantage of magneto ignition over battery ignition is that you obtain a hotter spark from the magneto ignition at high engine speeds.

96. To take the place of fuses in aircraft electrical systems, a circuit breaker or limitor lugs would be incorporated.

97. The purpose of the condenser in a high-tension magneto is to absorb the surge of the current, thereby assisting in the rapid collapsing of the primary circuit.

98. The neutral position of the rotating magnet in an aircraft magneto is when the flux flows equal to either pole or pole shoe.

99. When you employ two generators running at the same time and one generator is developing more voltage than the

other, the generator developing the greater voltage will try to hog the whole load. The generators will be synchronized by the use of voltage regulators.

100. If you had voltage and no amperage, the likely cause would be a blown fuse, a burned-out limitor lug, or open circuit breaker.

CHAPTER VI

ENGINE INSTRUMENTS

Instruments are of extreme importance to ensure proper and safe engine operation. Correct interpreting of the engine instruments is necessary to identify correct engine operation and to detect any malfunctioning of the engine.

The most important engine instruments are those for (1) oil pressure and temperature, (2) tachometer (r.p.m.) use, (3) fuel pressure, (4) carburetor air temperature, (5) cylinder temperature, (6) manifold pressure, and (7) fuel-air mixture ratio indicating.

Standard dial sizes are 1⅞ or two 2¾ in. Differential pressure gauges and absolute pressure gauges require airtight cases. Other instruments need raintight cases to keep out dust and moisture.

Various methods of lighting are employed, such as luminous paint, individual lighting, fluorescent lighting, reactance lighting, etc. Operation markings are painted on either the cover glass or the dial. Short radial lines (red) indicate maximum and minimum limits. Green and yellow arcs indicate cruising ranges.

Most instrument work comes under the heading of major repairs and requires special skill, tools and jigs, calibration equipment, etc. Delicate instruments are provided with stamped seals to prevent their being tampered with. Instruments are installed in shock panels and connected with flexible lines.

PRESSURE-TYPE INSTRUMENTS

The Bourdon-tube Principle.—Most pressure-type engine instruments employ the Bourdon-tube principle. This makes use of a metal tube formed in an arc and closed at one end.

The other end is open to receive pressure. This end is held stationary, while the opposite end is free to move. As pressure is applied, the tube tends to straighten out. The amount of movement being proportional to pressure, suitable linkage, levers, pinions, etc., move a pointer, which indicates the pressure on the dial face of the instrument.

Generally, gauges of this type, such as those for oil pressure and fuel pressure, have a small hole or restricted orifice at the engine connection to resist surging. A No. 60 drill (0.04 diameter) is used. Some installations incorporate a surge chamber to assist in this function.

Usually the fuel gauge, oil pressure gauge, and oil thermometer are incorporated in one unit under one cover glass, to reduce frontal space. If one of the three gauges becomes inoperative, it is necessary to replace the entire unit. Fuel pressure gauges and fuel warning gauges indicate the proper functioning of the fuel system. The warning gauge operates a light or some other signal when the fuel pressure drops below a predetermined point.

To minimize danger from fire, modern installations use a diaphragm in the line near the engine. The pressure is directed against the diaphragm by the fuel but is led to the instrument panel by a noninflammable liquid.

Oil pressure and oil pressure warning gauges function the same as the fuel gauges, their purpose, of course, being to indicate oil pressure or lack of pressure. During cold-weather operation, the oil pressure gauge line is filled with instrument oil to prevent sluggish operation of the gauge.

Manifold Pressure Gauges.—The manifold pressure gauge is essentially a barometer. It is used to measure pressures at the cylinder entrance or inlet port. With the engine inoperative, it indicates atmospheric pressures.

Engine horsepower is proportional to its air consumption (weight). The rate of using or consuming air is dependent upon the number of suction strokes per minute (r.p.m.) and the amount or weight of the air fed to the engine. If rated

take-off horsepower is exceeded, damage to the engine may result. The manifold pressure gauge serves to notify the operator of the limits of safe power output, and serves also as a means of adjusting external-type superchargers and automatic or adjustable propellers. It serves, besides, to indicate loss of engine power at altitude. It is calibrated in inches of mercury (Hg.). One pound per square inch equals 2.03 in. Hg.

Pressures above atmospheric are known as *boosts*. Manufacturers' recommendations should be followed for desired and maximum manifold pressures for various operating conditions.

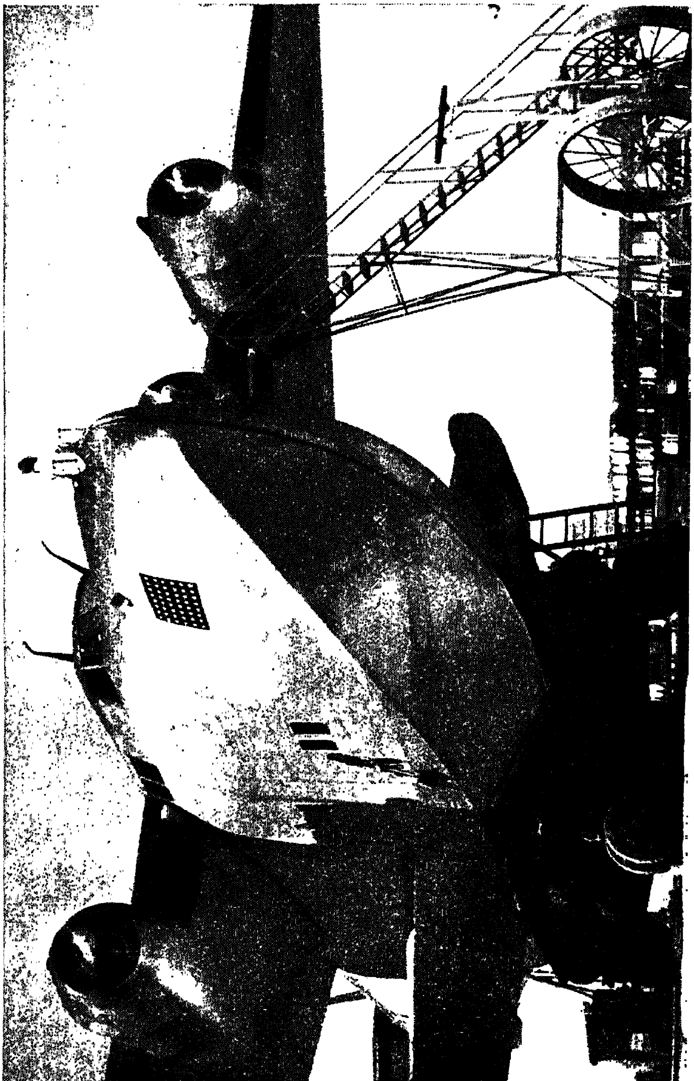
Temperature Indicators.—Temperature gauges are of two types: (1) vapor-pressure thermometer, (2) electrically operating thermometers.

Vapor-pressure Thermometers.—Vapor-pressure types consist of a bulb, a capillary tube, and an indicator. They are filled with a volatile liquid (methyl chloride). The expansion of the fluid resulting from heat in the sealed unit is transmitted to a Bourdon-tube mechanism. This registers on the dial of the instrument. If the capillary tube becomes broken, it is not repairable but must be replaced.

Electric Thermometers.—Electrically operating thermometers serve the same purpose as the vapor-pressure type. They have the added advantage that several thermometers can be connected to one indicator unit. A switch (selector) connects the unit for multireadings, such as those on a four-engine airplane.

The operating principle of electric thermometers depends upon the electrical resistance of metals changing with variations in temperature. Changes of resistance due to temperature changes vary the amount of current flowing in the circuit. This current change is measured by the indicator in degrees of temperature.

Thermocouples.—Thermocouples are used to measure cylinder temperatures on air-cooled engines. They consist of



All work signed off, engines are being warmed up.

dissimilar metals (constantan) connected to an indicator (D'Arsonval type). They indicate temperature changes by measuring the electrical resistance of the circuit as it changes with temperature.

TACHOMETERS

Tachometers are of various general types. They all function to indicate engine crankshaft speed (r.p.m.). With constant-speed and adjustable-pitch propellers, they function in determining propeller speed.

Centrifugal, magnetic, and chronometric types are rapidly being replaced by generator-voltmeter tachometers. These consist of an a.c. or a d.c. generator connected to the engine. A set of lead wires and a voltmeter complete the device. Generator output increases with speed, calibrating the voltmeter in r.p.m. gives engine speed directly on the indicator. Engine synchronism indicators also use this principle.

REMOTE INDICATING INSTRUMENTS

Remote indicating instruments have been developed to measure engine functions. They eliminate long-drive shafts, tubing, oil congealing, fire hazard, weight, etc. They are manufactured under such trade names as Telegon, Autosyn, Selsyn, etc. They operate electrically, usually employing multiple indicators. Among the engine functions that they are used to indicate are (1) fuel and oil pressure, (2) manifold pressure, (3) engine r.p.m., (4) fuel level and fuel flow, and (5) oil temperature.

FUEL-MIXTURE ANALYZERS

Fuel-mixture indicators (exhaust-gas analyzers) are used to indicate fuel-air mixture ratios. They provide a means of setting the mixture control. These instruments consist of an indicator unit and an analyzer cell. Exhaust-gas samples are analyzed (broken down) and from this the fuel-air ratio is determined. Exhaust gases consist of carbon dioxide (CO_2), carbon monoxide (CO), oxygen (O_2), hydrogen (H_2),

and nitrogen (N_2). The proportion of these gases is directly related to the fuel-air mixture. The instrument functions by measuring the amount of hydrogen and carbon dioxide present in the exhaust gases. Thermal conductivity of H_2 is about six times that of air; CO_2, one-half that of air. The instrument functions in measuring the thermal conductivity as these gases change in their proportions according to various fuel-air ratios.

One exception to the normal functioning of the fuel-air ratio mixture indicator occurs when detonation takes place. When detonation sets in, excessive amounts of H_2 are liberated. This will cause the indicator to swing to the rich side, whereas the mixture remains dangerously lean. This departure from normal functioning may be used in detecting detonation.

MULTIPLE-CHOICE QUESTIONS*

1. A manifold pressure gauge is calibrated in
a. pounds per square inch
b. inches of mercury above atmospheric pressure
c. revolutions per minute
d. degrees centigrade or Fahrenheit
e. inches of mercury above absolute pressure

2. To prevent serious damage to the manifold pressure gauge resulting from backfire,
a. the instrument is mounted on a shockproof panel
b. the instrument is equipped with a dampener in the inlet fitting
c. a by-pass is installed in the line to relieve the excess pressures
d. a heavy spring keeps the pointer from going beyond limits
e. a plug is used

3. A manifold pressure gauge is connected
a. from intake manifold to the inside of the diaphragm

* A key to the answers is given on p. 180.

b. from the low-pressure area in the carburetor to the case
c. from the intake manifold to the instrument-case fitting
d. from the air scoop to the diaphragm
e. from the rear section to the instrument case

4. The threads of the nipple that are inserted into a tube connecting instrument are
a. a Parker-Kalon screw thread
b. a ½-in. taper pipe thread
c. a ⅛-in. U.S. standard thread
d. a ⅛-in. American standard tapered pipe thread
e. a 9⁄16-in. S.A.E. thread

5. The reading (at sea level) of a manifold pressure gauge of an inoperative engine should be about
a. 0 in. of mercury
b. 14.7 in. of mercury
c. the same as a good temperature gauge
d. 29.9 in. of mercury
e. the same as a good air-speed indicator

6. A fuel pressure gauge
a. prevents excessive pressures from building up in line
b. maintains proper pressures at the inlet of the carburetor
c. indicates pressure at the inlet of the carburetor
d. maintains pressure between the wobble pump and the engine
e. indicates the quantity of fuel passing through the pump into the carburetor

7. A vapor-pressure thermometer contains
a. constantan
b. mercury
c. alcohol
d. eythol glycol
e. methyl chloride

8. A vapor-pressure thermometer (to register) depends upon
a. the expansion of the liquid
b. the vapor pressure
c. the expansion of the bulb

d. the pressure on the outside of the bulb
e. the potential that is set up by the capillary

9. A broken capillary
a. may be repaired by filling it with proper liquid and soldering the tube together
b. may be repaired by replacing the damaged portion by splicing a new piece to it
c. cannot be repaired
d. may be repaired by installing a new capillary
e. may be left to the mechanic to decide whether it can be repaired or not

10. A strobator is used
a. to test thermometers
b. to synchronize the engines on a twin-engine airplane
c. to check the accuracy of tachometers
d. to measure the heat of cylinders
e. to check exhaust flames on engines at night

11. The following set of instruments employs Bourdon tubes:
a. tachometer, fuel pressure, and oil temperature gauges
b. oil pressure, fuel pressure, manifold pressure gauges
c. vapor pressure thermometer, fuel pressure gauge, and oil temperature gauge
d. air thermometers, liquid thermometers, and manifold pressure gauges
e. fuel-level gauge, oil-quantity gauge, and oil pressure gauge

12. A liquid thermometer is filled with
a. sodium chloride
b. mercury
c. methyl chloride
d. water
e. methyl ether

13. A raintight case is used on
a. manifold pressure gauge

b. oil pressure gauge
c. altometer
d. sensitive differential pressure gauge
e. absolute pressure gauge

14. An airtight case is used on
a. the more rugged type of instrument
b. oil pressure gauge
c. oil temperature gauge
d. fuel pressure gauge
e. manifold pressure gauge

15. Which of the following systems would be used to register the r.p.m. of the outboard engines in a four-engine plane?
a. chronometric tachometer
b. generator voltmeter tachometer
c. magnetic tachometer
d. centrifugal tachometer

16. To increase the operating range of a Bourdon-tube instrument, it would be necessary to
a. use a thinner Bourdon tube
b. reset the pointer
c. use a stiffer, heavier gauge metal on the Bourdon tube
d. flatten out the original Bourdon tube to allow more expansion

17. Oil pressure gauges are connected
a. at the outlet from the engine
b. at the outlet side of the pressure oil strainer
c. at the entrance to the oil radiator
d. directly to the sump

18. Selector switches are used on electrically operated thermometers
a. to select desired temperatures
b. to aid in rapid engine warm-up
c. to vary engine temperatures
d. to permit one indicator unit, indicating several thermometer locations

19. A manifold pressure gauge is essentially a
a. barometer
b. thermometer
c. fuel-quantity gauge
d. synchronism device
20. Fuel-air mixture ratio analyzers
a. supply fuel and air to the engine
b. indicate mixture strengths
c. mix fuel and air together
d. functions only at high altitudes
21. Oil and fuel warning gauges indicate
a. excessive pressure
b. normal pressure
c. lack of normal pressure
d. high pressure only
22. Manifold pressure is indicated in
a. pounds per square inch
b. inches of mercury
c. pounds of mercury
d. feet per second
23. Engine r.p.m. shown on the tachometer indicates
a. crankshaft speed
b. camshaft speed
c. piston speed
d. propeller speed
24. Instruments are mounted on a shockproof panel
a. to resist high-frequency currents
b. to absorb vibration and shock
c. to mount them so is not necessary
d. to avoid electric shocks
25. To check operation of a fuel warning gauge you would use the
a. wobble pump
b. starter
c. liquidometer
d. fuel-flow meter

ESSAY-TYPE QUESTIONS*

26. Does the standard method of shockproofing instrument panels eliminate all vibration?

27. Name two ways in which aircraft instruments are sealed.

28. What is indicated by a radial red line on the cover glass of an air-speed indicator?

29. Name two general classes of instruments that normally do not read zero when the airplane and the engine are inoperative.

30. Where are flight instruments normally located in an airplane?

31. What is the purpose of the fuel pressure gauge?

32. What is the purpose of the manifold pressure gauge?

33. When the engine is inoperative, what pressure is indicated by the manifold pressure gauges?

34. Why is the drain cock located in the manifold pressure gauge?

35. When the engine is idling, why should the pointer on the manifold pressure gauge move to the left?

36. Will an oil pressure gauge indicate an exhausted oil supply?

37. What is the purpose of a surge chamber in an oil pressure line?

38. Why are chronometric tachometers restricted to use on single-engine airplanes?

39. What are the three principal units of the electric tachometer?

40. Why is it important that the speeds (r.p.m.) on a bimotored airplane be synchronized?

41. What is the purpose of the condenser unit that is built into the metal shield of the eclipse synchroscope?

42. What is the boiling point of ethylene glycol at sea level?

43. What is the purpose of the cylinder temperature gauge?

* Answers are given on p. 180.

44. Is it permissible to lengthen or shorten the thermocouple leads of the cylinder temperature gauge?

45. What is the purpose of the fuel-mixture indicator?

46. How will the use of a carburetor air heater affect the fuel-air ratio?

47. For what purposes are Selsyn instruments used?

48. From what source is the current supplied for the operation of Selsyn instruments?

49. Under what conditions will the air-speed indicator show the correct ground speed?

50. For what two distinct purposes are altimeters used in aircraft?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 174

1. *e*	2. *b*	3. *c*	4. *c*	5. *d*	6. *c*
7. *e*	8. *b*	9. *c*	10. *b*	11. *b*	12. *c*
13. *b*	14. *e*	15. *b*	16. *c*	17. *b*	18. *d*
19. *a*	20. *b*	21. *c*	22. *b*	23. *a*	24. *b*
25. *a*					

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 179

26. Aircraft instruments must function satisfactorily under vibration. Since this may be excessive at certain times, all instruments are mounted on shockproof panels, which minimize amplitude and frequencies of vibration to which the instrument is subjected. However, standard methods of shockproofing in use do not eliminate all vibration; consequently, the instruments are designed to function accurately only when subjected to some vibration.

27. Two methods of sealing instruments are to make them raintight and airtight.

28. Owing to the wide divergence in operating temperatures, pressures, and speeds, it is necessary to paint operation markings of various colors on the cover glasses of some of the instruments. Air-speed indicators installed in aircraft are marked with a red line extending from the center of the dial and passing directly over the point corresponding to the

maximum permissible indicated air speed. The maximum permissible indicated air speed for each type of airplane is that specified in the aircraft manufacturer's instructions.

29. Two instruments that normally do not read zero when the airplane and the engine are inoperative are manifold pressure gauges and thermometers.

30. Flight instruments are normally located on the pilot's instrument panel.

31. The purpose of the fuel pressure gauge is to measure and indicate the difference between air and fuel pressure at their respective inlets to the carburetor. The specific uses of this measurement are to warn the pilot of impending engine failure of the fuel pump, broken fuel line, or many other causes that prevent the fuel from reaching the carburetors under sufficient pressure. Also, to indicate that fuel is being supplied to the carburetors steadily under the proper pressure before take-off.

32. The purpose of the manifold gauge is to show manifold pressures under various engine operating conditions when the engine is equipped with a supercharger, one of its main purposes being to prevent oversupercharging when operating at low altitudes, also to indicate safe power output of engines.

33. When the engine is inoperative, the manifold pressure gauge should read sea-level pressure, 29.92.

34. A drain cock is located in the line as close to the instrument connection as possible, for clean-out purposes. The manifold pressure gauge line should always be drained at idling speeds.

35. With the engine idling, the pointer should always move to the left, since the absolute pressure in the manifold would be low, that is, 10 to 15 in. Hg. As the throttle is advanced and the engine r.p.m. increases, the pointer on the gauge should move to the right, or in a clockwise direction.

36. Oil pressure gauges are required on all types of aircraft engines to show the pressure at which the lubricant is being forced to the bearings and the various other points of the lubricating system. Some of the specific uses of the oil pres-

sure gauge are to warn the pilot of impending engine failure caused by exhausted oil supply, failure of the oil pump, burned-out bearings, broken oil lines, etc.

37. Engines that operate at pressures above 100 lb. per sq. in. must incorporate a surge chamber connected into the line. The air that is trapped in the surge chamber, when the line is connected to the instrument, serves as a cushion for the pulsations in the oil pressure caused by the pump. This eliminates the hammer effect on the mechanism on the gauge and prevents oscillation of the instrument.

38. Chronometric tachometers are used on some aircraft to measure the speed of the engine crankshaft. The chronometric tachometer is very rugged and gives long periods of service with minimum maintenance and repair; however, its use is limited to single-engine airplanes because it is shaft driven. Unsatisfactory operation results when the shaft length exceeds 20 ft. or when the shaft must have an excessive amount and number of bends.

39. The three principal units of a generator voltmeter are the indicator, which is mounted on the instrument panel; the generator, which is attached to the tachometer drive of the engine; and the connecting leads, which are insulated low-voltage cable.

40. It is important that the speeds of the engines on a bi-motored airplane be synchronized to reduce vibration and objectionable pulsations of the engine, and attendant noise and discomfort.

41. A condenser unit is built into a metal shield to provide a smooth pointer movement and to prevent excessive oscillation caused by slight variations in frequencies.

42. The boiling point of ethylene glycol is 192° C. at sea level.

43. The purpose of a cylinder temperature gauge is to measure and indicate the temperature of air-cooled engines at some point on one of the cylinders. Usually, this is the master-rod cylinder, as that is the hottest running cylinder.

44. The thermocouple leads must not be lengthened or shortened, as they are of a definite resistance and enter into the calibration of the indicator.

45. The fuel-mixture indicator (exhaust-gas analyzer) is an instrument that indicates fuel-air ratio of the mixture entering the engine. This instrument is used as a guide to the pilot in setting mixture control.

46. When carburetor air heaters are used, the mixture indication very definitely goes rich, and if prolonged running is to be done while using the air heater, the mixture should be reset after applying the heat.

47. Selsyn instruments are used as position indicators, to show the position of wing flaps, electrically operated cowl flaps, landing wheels, etc.

48. A Selsyn is a d.c. (direct-current) operated instrument.

49. Except in still air at normal sea-level atmospheric pressure, the indicated air speed is different from the ground speed. However, the pilot may calculate ground speed from the indicated air speed if he knows the altitude at which he is flying and the direction and the speed of the wind.

50. Altimeters are used for two distinct purposes: to measure the elevation of the aircraft above sea level and to measure the elevation of the aircraft above some point on the ground, regardless of its elevation above sea level.

CHAPTER VII

ENGINE OPERATION AND TEST

Engine operation depends to a great extent on the knowledge and skill of the operator. Rapid developments have taken place, and the mechanic and flight engineer have assumed greater importance in actual operation. The increasing use of large multi-engine equipment, higher power output, highly supercharged engines, and constant-speed propellers calls for a capable interpreting of instruments and controls.

ENGINE CONTROLS

Engine controls may be classified as (1) automatic, (2) semiautomatic, and (3) manual. In general, they consist of the mechanisms that operate engines and engine accessories.

They are generally actuated by levers, push-pull rods, and bell cranks or, in some instances, by electrically operated mechanisms and hydraulic controls. The function is identical in any case—that is, to operate the engine controls. Electronics may be expected to assume some of these necessary operations. The trend is toward automatic controls, thereby relieving the operator for other duties.

Functions of the Controls.—Among the more important controls are (1) the throttle, (2) the mixture control, (3) the carburetor air heat, (4) the supercharger, (5) shutters or flaps, and (6) the propeller. The limiting factors are critical engine speed, temperatures, and pressures. Improper operation can quickly ruin an engine.

Throttle.—The throttle is considered the most important control, as its movement determines the speed and power of the engine. Some throttles incorporate a stop, to prevent exceeding safe manifold pressures below the critical altitude

of the engine. The throttle is marked with a *T* and is the most conspicuous control in a combined unit. The quadrant is marked Open and Closed.

Mixture Control.—The mixture control resembles the throttle. It is marked *M* and the quadrant reads Lean and Rich. Most modern mixture controls incorporate an idle cutoff feature that is used for stopping the engines at idling speeds.

Carburetor Heat Control.—The carburetor heat control is used to prevent icing in the carburetor. It is generally marked Cold and Hot and must be judiciously used by the operator.

Supercharger Controls.—Two types of supercharger controls are used, one to change the speed of a mechanically driven supercharger; the other, to operate exhaust turboblowers. The first type is marked High and Low, while the turbo control will be marked Off and On.

Flaps and Shutters.—Cowling flaps and shutters are generally marked Open and Closed. They regulate the air flow that cools the engine.

Propeller Controls.—Propeller controls depend upon the type of propeller used, and in general they are a means of permitting the operator to obtain maximum propeller efficiency.

Temperature Control.—Maximum safe temperatures are the most important controlling factor in engine operation. These temperatures are subject to control by the throttle, the mixture, carburetor air heat, shutters and flaps, oil temperature, and atmospheric conditions.

Cylinder-head temperatures are the most critical and the most rapid in detecting changes; therefore, they are used as the criterion for operating temperatures.

Throttle-control position governs the heat generated as a result of the rapidity of combustion events. It follows that opening the throttle increases engine temperature. The indicating factors are manifold pressure and the r.p.m. of the engine.

The mixture control governs the mixture strength. A lean mixture always burns more slowly. A slow-burning mixture liberates more heat to the cylinders. Therefore, a lean mixture will always increase engine temperature. On the other hand, a rich mixture actually fuel-cools the engine.

Atmospheric temperatures affect engine temperatures, which is obvious. Inferior grades of fuel cause overheating and detonation, resulting in abnormal temperatures.

The flaps govern the rate of air flow past the cylinders or radiators. Closing the flaps will increase temperatures. The shutters on the oil cooler have the same function. Closing the shutters increases the oil temperature, which, in turn, tends to increase engine temperature.

The hot air, as supplied by the carburetor air heater, will increase engine temperatures as a result of the slower rate of burning of the mixture and the increased initial temperature of the charge as it enters the cylinders.

Manifold pressures, if excessive, will cause overheating difficulties resulting from the increased density of the mixture and the subsequent heat liberation beyond the capacity of the cooling system to control.

In all cases of overheating, the throttle opening should be reduced and the mixture control placed in a full-rich position. Various automatic mixture controls have tended to eliminate the manual control.

On engines not equipped with a fuel-air ratio indicator, the propeller must be placed in a fixed position when the mixture control is being adjusted manually.

STARTING

Three conditions are necessary for an engine to start and to continue to run: (1) compression—to obtain a reasonable amount of work from the cylinders, and to aid in vaporizing the charge; (2) fuel and air—in the proper proportions to meet the conditions under which the engine is operated; (3)

an electric spark or flame to ignite the charge at the proper time.

On some small engines the cranking of the engine indirectly furnishes these requisites. On larger engines, the starter rotating the crankshaft furnishes the compression. The hand primer supplies the fuel; and the booster coil, the spark.

The specific starting procedures should be followed by the mechanic. These are readily available in the manufacturers' manuals. The general starting procedure is as follows:

1. Before starting any engine, the propeller should be pulled through by hand at least three to four revolutions. This will determine whether there is any oil in the cylinders. Radial engines are particularly susceptible to this condition. If any resistance is felt, further investigation is absolutely necessary. This step is very important.

2. Carburetor air-heater control should be placed in the Cold position. Otherwise, a backfire may damage the control valve.

3. Cowling flaps should be open.

4. The mixture control should be placed in Full Rich position and the throttle set for idling speed. The fuel cock should be turned on and the hand pump operated until the fuel pressure gauge reads the required pressure. This operation should be done easily, as excessive pumping may flood the carburetor and present a fire hazard. Pumping of the throttle should be avoided at all times.

5. If the engine is cold, it will be necessary to use the primer. This operation is performed while the starter is being energized. Correct operation of the primer requires that the plunger be pulled out slowly. This allows the fuel a chance to enter the pump. The plunger should be pushed in rapidly to aid in atomization of the primer charge through the primer nozzles. Four to six strokes are generally sufficient. After priming, the handle must be placed in the Off position. Hot engines, as a rule, do not require priming. Generally the throttle is opened wider when the engine is warm. Overpriming should

be avoided, as the lubricant may be washed from the cylinder walls. Loss of compression and rapid wear may result. It is advisable in this condition to add a teaspoonful of oil to each cylinder before attempting to start the engine.

If a hand inertia starter is used, it should be operated until the hand crank has a speed of about 75 r.p.m. Disengage the hand crank, then engage the starter dogs by pulling the control rod. This operation should be done as rapidly as possible in order to utilize as much of the stored energy as possible. If an electrically operated inertia starter is used, about 20 sec. operation is enough to energize the starter. The switch or control rod should be pulled out quickly and released immediately when the engine starts.

Most modern installations incorporate the energizing and engaging switches in a foot treadle, which also operates the booster coil when the starter jaws are engaged. If a hand-operated booster switch is used, it should be depressed when engaging the starter jaws and released when the engine runs on its own magnetos.

Modern engines incorporate an oil dilution system, to introduce a certain amount of fuel into the engine oil immediately before the engine stops. This is used during cold-weather operation to lower the viscosity of the oil. The engine will then be free from the heavy oil drag and will start quite readily. After the engine warms up, the gasoline is dissipated in fumes through the breather, as a result of the high operating temperatures of the engine.

When the oil dilution system is operated, the fuel pressure gauge will indicate proper operation by showing a pressure drop during the dilution period.

WARM-UP

This procedure is very important as it permits the parts to expand properly to running clearances and allows the oil to attain its proper viscosity.

The engine should not be operated faster than one-half maximum ground r.p.m. until the oil pressure gauge shows at least two-thirds minimum full-power oil pressure.

The oil temperature gauge should show a definite increase in temperature, which indicates that the oil is circulating properly. The engine, then, may be checked for proper functioning at the higher r.p.m., but full-power operation should not be maintained for over 20 to 30 sec. The maximum ground r.p.m. should never be exceeded.

Engines equipped with air deflectors or pressure baffles should be operated with caution. These engines will warm up rather quickly and, in some cases, will overheat during ground operation. The airplane should be placed into the wind when possible, and all flaps should be fully opened. Ground operation is limited on these engines and should be kept to a minimum.

Engines equipped with hydraulically controlled propellers should not be moved into the low-pitch position until a 30-sec. ground operation has elapsed. This is necessary to avoid possible oil starvation of the master rod due to the lack of lubrication during this operation.

The first step in warming up is to ascertain that the oil pressure gauge shows an indication. If it does not register within 30 sec., the engine should be immediately stopped and the cause determined. Circumstances warranting, carburetor heat control should then be moved to the hot position, and the propeller kept in low pitch.

Never attempt to warm an engine more quickly by closing the cowl flaps. This may cause the burning of the ignition wires at the spark-plug elbows.

ENGINE CHECK

In general, engine check consists of checking the proper operation of the power plant and its accessories. The gauges and controls are noted carefully. Also, the condition of the

engine may be determined by sound or unusual vibration. Anything unusual should be carefully investigated.

Make sure that all parts are functioning properly. In flight, any departure from the normal can readily be detected by the instruments and controls.

When a constant-speed propeller is used, the engine r.p.m. at cruising power on the ground is lower than the r.p.m. the constant-speed control is set to govern. Therefore, the propeller will remain in low pitch, and the r.p.m. will vary with the throttle opening.

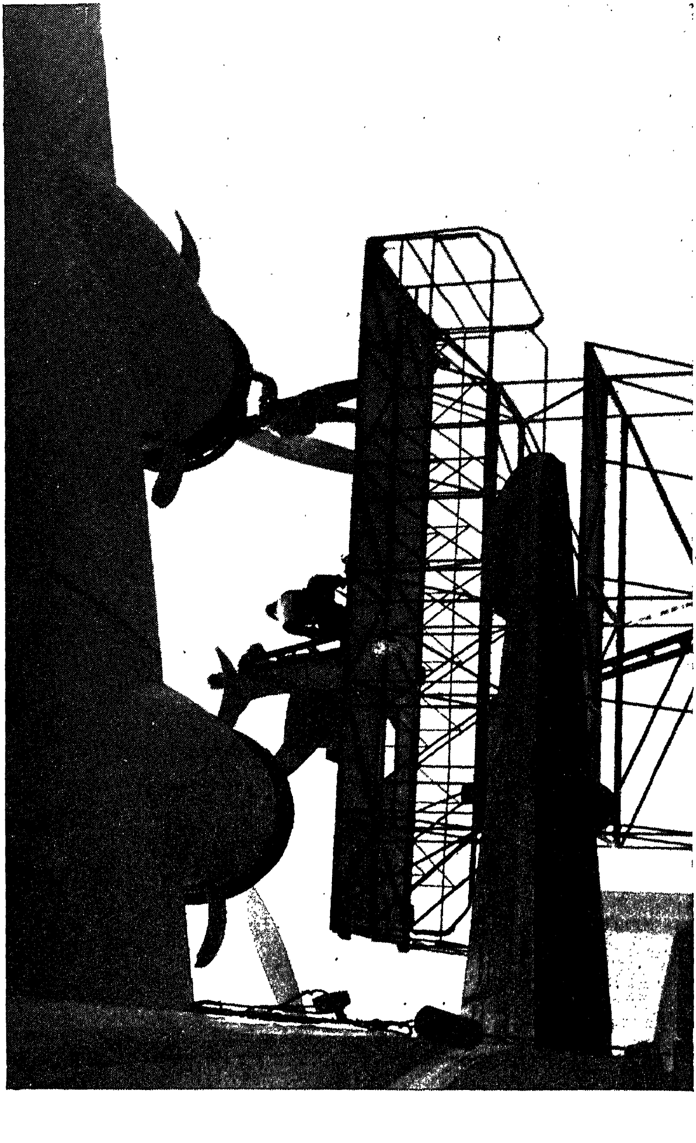
Smoothness of operation, r.p.m., manifold pressure, cylinder temperature, oil temperature, and oil pressure are the indicating factors in checking the power plant.

In checking the operation of a two-speed supercharger, the clutch is placed in the High position. When the engine has stabilized, the manifold pressure is carefully noted and the clutch is shifted to the Low position. A decrease in manifold pressure should be noted.

Controllable propellers are checked by noting the engine r.p.m. as the propeller controls are operated. Tachometer pointers should not show wide or rapid oscillations.

FLIGHT

The operation of the engine in flight is beyond the scope of this volume. However, a few general points may be discussed here. The power output of an engine is almost directly proportional to its air consumption, assuming that the fuel-air ratio remains constant. The air consumption is dependent upon the density of the air at the intake ports (manifold pressure) and the number of suction strokes per minute. Secondary factors are air-inlet temperatures and exhaust-outlet pressures. Therefore, it follows that the engine horsepower may be specified in terms of manifold pressure and crankshaft r.p.m. The selection of the proper power output of the engine is specified in the operation instruction manual for the particular engine.



Lofty mechanics' work stands are necessary for the "big ones."

STOPPING

The accepted procedure for stopping engines is to minimize afterfiring, backfiring, and kickback, all of which are injurious to the engine. *Afterfiring* may be defined as the engine's continuing to run after the switch has been cut off. *Backfiring* is generally due to the cylinder's firing back to the carburetor as a result of the early intake-valve opening, or a condition such as a sticking intake valve. *Kickback* means that combustion is completed before the piston has passed through top dead center and the expansion of the burning gases drives the piston backward against the direction of rotation. This can happen only on one cylinder. The engine should be idled for a sufficient length of time to allow the cylinder temperatures to drop below minimum normal operating temperatures. All engines are stopped by cutting off either the ignition or the fuel supply. Most modern carburetors incorporate an idle cutoff feature. This idle cutoff valve is actuated by placing the mixture control in the Full Lean position, with the engine idling. The engine will cut out rather abruptly.

The ignition switch should then be placed in the Off position. The throttle should be placed fully open, to minimize danger of accidental starting.

Electric and hydromatic propellers are stopped in a Low position, while counterweight type propellers are placed in the high pitch before stopping. This will protect the piston from dirt and corrosion, it will also prevent the oil's congealing in cold weather and will aid in shifting to high pitch.

Engines equipped with oil dilution systems are diluted during the last several minutes of engine operation. The fuel pressure will drop almost to zero when operating the oil dilution control. This indicates that the system is functioning properly. The length of time necessary for dilution is determined by the atmospheric temperature and the particular characteristics of the engine.

Modern lubricants are chemically treated to assist them in maintaining their viscosity at various extremes of temperatures.

MULTIPLE-CHOICE QUESTIONS*

1. When an aircraft engine is equipped with a preheater, the engine is started with the control in the Cold position, to prevent

a. too lean a mixture
b. damage to the preheater valve in case of backfire
c. a fire hazard
d. too low air density

2. In starting an aircraft engine equipped with a Hamilton two-position or constant-speed propeller, it is necessary that the propeller control be normally placed in the high-pitch (decreased r.p.m.) position to

a. make the engine start more easily
b. slow the engine down as it starts
c. avoid starving the master-rod bearing of oil
d. cause the engine to heat more rapidly

3. The following reasons are given for the cylinder-head temperature of an aircraft engine being taken from the master-rod cylinder (select one):

a. it is more readily accessible than any other cylinder
b. it is the only cylinder equipped for the thermocouple installation
c. it is so constructed as to offer better cooling than any other cylinder
d. this cylinder has higher operating temperatures

4. In operating an aircraft engine on one magneto at a time the specified operating limit, not to be exceeded, is

a. one-third throttle
b. cruising manifold pressure
c. 1,500 r.p.m.
d. 800–1,000 r.p.m.

* A key to the answers is given on p. 215.

5. The automatic Cuno strainer is checked for operation by

a. checking the oil pressure after the engine is warmed up

b. removing the Cuno shaft cap, with the engine running, and checking for rotation

c. removing the Cuno and checking by hand rotation

d. checking the shaft for rotation without removing the shaft

6. Except for permanent connections, aluminum male pipe threads must not be used with female pipe threads. The reason is that

a. the threads will seize, preventing dismantling of the unit

b. a tight seal cannot be obtained at high pressures

c. electrolytic action will take place

d. corrosion will result

7. In operating the oil dilution valve on engine installations employing this feature, the reason for avoiding excessive oil dilution is

a. to prevent the overheating of the engine

b. to save fuel

c. to prevent excessive drop in fuel pressure

d. to prevent interference with proper scavenging of the oil from the engine

8. If during cold-weather operation the oil pressure gauge reading appeared to be sluggish, which of the following instructions would apply?

a. disregard the gauge until the oil warms up

b. use a lighter grade of oil in the engine

c. warm the oil pressure gauge line

d. fill the oil pressure gauge line with instrument oil

9. In an aircraft engine oil system, in which of the following locations will the oil temperature bulb be located?

a. oil-inlet side of the engine

b. oil-outlet side of the engine

c. oil tank

d. oil sump

10. The use of an inferior grade of fuel in an aircraft engine may result in

a. increase in heat efficiency of the engine
b. detonation at high speeds or under full-load conditions, resulting in damage to the engine
c. cooling the engine operating temperatures
d. injury to the fuel system

11. If the flywheel of an inertia starter fails to rotate the crankshaft, even though it is rotating at 12,000 r.p.m. when engaged, the probable cause of the trouble is

a. too-high flywheel r.p.m.
b. broken starter shaft
c. the clutch is slipping
d. failure of the electrical equipment

12. In the installation of storage-battery leads, what is the proper order of installation?

a. lead, lock washer, plain washer, wing nut
b. lock washer, lead, plain washer, wing nut
c. lead, plain washer, lock washer, wing nut
d. lock washer, plain washer, lead, wing nut

13. Which of the following statements is true, in case of failure of a cartridge to fire when operating a type E-3 or E-4 cartridge starter?

a. no additional attempts to fire it are made
b. the breech shall not be opened for at least 5 min.
c. it may be removed from the breech and a new cartridge inserted when 1 min. has elapsed
d. the firing pin and breech is tapped with any appropriate object

14. In adjusting the voltage regulator of the A-1 generator control panel

a. the line switch must be open
b. the line switch must be closed
c. the line switch must be closed and some load must be on the line, such as lights
d. the line switch must be open and a load be on the line

15. During the operation of an aircraft engine, the fuel pressure signal light should burn steadily under which of the following conditions?

a. when the desired fuel pressure is maintained
b. when the fuel pressure drops below a predetermined point
c. as soon as the fuel cocks are turned on and operating fuel pressure is reached
d. as soon as the magneto switch is placed in the off position

16. From the following list select the maintenance operation that is performed on the preflight inspection of a manifold pressure gauge:

a. fill the line with instrument oil
b. adjust the zero setting
c. clean the screens
d. drain the line

17. When it is fully charged, the specific gravity reading of a lead-acid storage battery should be

a. 1.100 to 1.150
b. 1.225 to 1.250
c. 1.275 to 1.285
d. over 1.300

18. If, during an inspection, one-half of a split-type propeller cone is found to be defective, what disposition is made of the remaining half?

a. both halves are discarded and a complete new set is installed
b. it is turned in to the supply, to be matched with a like part
c. a new half is requisitioned and matched with the good half and installed
d. the defective cone is refinished and reinstalled

19. Which of the following methods is recommended for changing the pitch of a Hamilton two-position propeller when it is installed and the engine is not in operation?

a. by tapping the cylinder with a mallet
b. by use of blade beams
c. by use of a bar behind the cylinder
d. by exerting pressure on the cylinder with the hands

20. Which of the following lubricants should be used on the propeller shaft in installing a propeller?

a. grease
b. graphite
c. engine oil
d. lard oil

21. When the propeller shaft on an aircraft engine is found to be nicked, galled, scored, or corroded, the raised portions of the defect will be

a. disregarded if the propeller slips on with ease
b. carefully dressed off by hand stoning
c. smoothed with a ball-peen hammer
d. dressed with emery cloth

22. In installing a spark plug in an aircraft engine, it is advisable to use spark-plug lubricant specification 3578 on the threads of the plug, to

a. provide an insulating substance to reduce plug temperature
b. permit installing the plug tighter in position
c. prevent the plug from seizing in position
d. prevent leakage around the plug

23. In checking the wiring of a distributor on a conventional nine-cylinder radial engine, No. 1 wire goes to No. 1 cylinder, No. 3 wire goes to

a. No. 2 cylinder
b. No. 3 cylinder
c. No. 4 cylinder
d. No. 5 cylinder

24. When a valve clearance is being checked on a radial aircraft engine, the piston should be

a. on BC of intake stroke
b. on TC of exhaust stroke

c. on BC of power stroke
d. on TC of compression stroke

25. In checking the valve timing on No. 1 cylinder of a nine-cylinder single-row radial engine, the hot running clearance specification must be temporarily incorporated to

a. ensure that the push rods are seating properly
b. ensure proper valve-spring operation at high operating temperatures
c. ensure proper valve timing at high operating temperatures
d. ensure proper lubrication of the valve mechanisms

26. If it is necessary to check both the valve and the ignition timing in an aircraft engine, the valve timing must be accomplished before the ignition timing, because

a. valve clearance adjustments cannot be made with the ignition units in place
b. after the spark plugs are installed, the compression in the cylinders may move the crankshaft after it has been placed in its proper position for timing
c. the compression stroke in a cylinder cannot be determined until the valves are timed
d. adjusting the magneto breaker-point clearance will change the valve timing

27. When, in preparing an aircraft engine for service after it has been in storage, it is found that several valve stems are sticking, they should be lubricated with

a. castor oil
b. penetrating oil
c. kerosene and lubricating oil solution
d. gasoline and lubricating oil solution

28. The throttle control of an aircraft engine is prevented from creeping by the use of

a. a throttle stop
b. an automatic stop
c. a friction clutch
d. ball-and-socket joints

29. Pressure baffles or deflectors are installed on high-powered radial engines to provide for

a. strengthening of the cylinders
b. better cooling of the cylinders on the ground
c. better cooling of the cylinders in the air
d. cooling of the engine accessories

30. The speed at which an automatic Cuno oil strainer installed in an aircraft turns depends upon the

a. speed of the engine
b. oil pressure and oil temperature
c. gear ratio between the Cuno and the engine's drive assembly
d. speed of the aircraft

31. In a modern aircraft fuel system, the change-over from one tank to another should be made immediately when

a. a loss of engine r.p.m. is indicated
b. a loss of manifold pressure is indicated
c. the fuel-system signal indicates a loss of pressure
d. the fuel tank gauge registers zero

32. In tightening ⅜-in. engine-mount bolts, the proper tightness as indicated on the torque wrench should be

a. 250 to 350 ft.-lb.
b. 250 to 350 in.-lb.
c. 300 to 500 in.-lb.
d. 350 to 400 in.-lb.

33. In installing mounting-ring rubber grommets, the bolts, bushings, and washers should be coated lightly with

a. grease
b. petrolatum
c. engine oil
d. castor oil

34. Cone unions are attached to copper tubing by means of

a. soft solder
b. brazing
c. silver solder
d. welding

35. Fuel- and oil-resistant flexible hose is identified by
a. a red stripe running the length of the hose
b. a red and a white stripe running the length of the hose
c. a white stripe running the length of the hose
d. two red stripes running the length of the hose

36. If the fuel- and oil-resistant hose is used,
a. a double set of hose clamps is always necessary
b. no hose liner is required
c. a hose liner is required
d. only a single set of hose clamps is always necessary

37. If corrosion is found on battery terminal leads, it should be removed with
a. baking-soda solution
b. petrolatum
c. kerosene
d. unleaded gasoline

38. The advantage in the use of a hopper tank is that
a. it has a greater oil capacity
b. it has a better venting system
c. it permits the use of an oil dilution system
d. it regulates the temperature of the oil

39. Engines equipped with an exhaust-driven turbosupercharger must have incorporated in the fuel system one of the following:
a. a by-pass valve
b. a wobble pump
c. a fuel pressure gauge
d. sylphon (bellows)-type fuel pressure relief valve

40. The approximate speed of a hand inertia starter, when starting an engine, should be
a. 20 sec. after starting
b. 40 to 50 r.p.m.
c. 80 to 100 r.p.m.
d. 70 to 80 r.p.m.
e. 50 to 70 r.p.m.

41. In most airplanes, one of the following indications is observed when the oil dilution valve is operated:

a. an increase in oil pressure
b. a loss of r.p.m.
c. a drop in fuel pressure
d. an increase in manifold pressure

42. The manifold pressure reading of an idling speed engine is about

a. 50 in. Hg
b. 15 in. Hg
c. 29.9 lb. per sq. in.
d. 15 lb. per sq. in.
e. 29.9 lb. Hg

43. Bonding braid will be connected to shielding braid by

a. clamping
b. bolting
c. machine screws
d. soldering

44. On an inflatable rubber-shoe type of deicer system, the operation check would be given

a. on 50-hr. inspection
b. on 25-hr. inspection
c. in preflight inspection
d. only when first installed

45. A fuel pressure gauge

a. prevents excessive pressures from building up in the line
b. maintains proper pressures at the inlet of the carburetor
c. indicates pressure at the inlet of the carburetor
d. maintains pressure between the wobble pump and the engine
e. indicates the quantity of fuel passing through the pump into the carburetor

46. In the oil dilution system, gasoline is added to the oil system at one of the following points:

a. the oil pressure chamber
b. the oil temperature regulator

c. the oil inlet line to the engine
d. the oil tank

47. The propeller is pulled through by hand before starting the engine
a. to determine if the articulating rods are loose
b. to help clear any foul spark plugs
c. to determine if there is any oil in the lower cylinders
d. to help to prime the engine
e. to ensure proper valve action

48. A leaky intake pipe will have most effect at
a. low altitudes only
b. all speeds
c. medium and high speeds
d. low and medium speeds
e. high altitudes only

49. After the switch has been cut off, an engine will continue to run as a result of
a. excessively overheated engine
b. too high a float level in the carburetor
c. switch shorted
d. both primary wires being shorted to the frame
e. opening the throttle too wide

50. An engine is usually subjected to its highest temperatures during
a. high-altitude operation
b. cruising speed
c. periods of engine check, take-off, and climb
d. an approach for a landing
e. hot-weather operation

51. Pressure baffles or deflectors are installed on high-powered radial engines to provide for
a. better cooling of the engine accessories
b. strengthening of the cylinders
c. better cooling on the ground
d. better cooling in the air
e. keeping the engine cool at low speeds

52. Rich best power is obtained

a. by moving the throttle to obtain the highest r.p.m.

b. by operating the accelerating pump for more fuel

c. by leaning out the mixture from full rich to a point just before the r.p.m. begins to drop

d. by leaning out the mixture from full rich until highest r.p.m. is obtained, with throttle and propeller set

e. by setting the propeller pitch to obtain the highest r.p.m.

53. The purpose of an air scoop on low-horsepower engines is to

a. give a ramming supercharger effect

b. cool the accessories

c. cool the cabin

d. decrease the volumetric efficiency of the engine

e. help cool the engine while on the ground

54. In order to check all valve clearances on a nine-cylinder radial engine, it is necessary to turn the crankshaft

a. two revolutions

b. five revolutions

c. four revolutions

d. nine revolutions

55. When a magneto is checked for loss of r.p.m., the test should take no longer than

a. 30 sec.

b. 1 min.

c. 15 sec.

d. 20 sec.

56. When a hot engine is being started,

a. it should be primed as soon as the starter is engaged to the engine

b. it should not be primed

c. it should be primed at least five strokes of the hand primer

d. it should be primed until the engine runs evenly

e. its priming depends on the size of the engine

57. The type of gasket used when a spark plug is installed in a cylinder is

a. vellumoid

b. solid copper

c. copper and asbestos

d. lead

58. The maximum torque permissible in tightening spark plugs in a cylinder is

a. 250 ft.-lb.

b. 480 in.-lb.

c. 380 in.-lb.

d. 480 ft.-lb.

59. All accessible fuel strainers will be drained

a. when necessary

b. every 100 hr.

c. every 50 hr.

d. preflight

e. every 200 hr.

60. A bluish-white flame from the exhaust stack, usually noticed when taking a magneto check, would indicate

a. rich mixture

b. lean mixture

c. defective spark plugs

d. correct mixture

e. incomplete combustion

61. When an engine equipped with a turbosupercharger is being started, the waste gate will be

a. halfway open

b. closed

c. open

d. in any position

62. Cylinder hold-down stud nuts on radial engines will be checked for tightness at

a. 50-hr. inspection

b. 200-hr. inspection

c. 25 hr. after engine change and every 100 hr.
d. daily inspection

63. The manifold pressure gauge drain cock should be vented at

a. idling speeds
b. 1,200 r.p.m.
c. cruising r.p.m.
d. maximum r.p.m.

64. It is undesirable to overprime an engine with the primer pump because

a. it floods the carburetor
b. it washes the film of oil from the cylinder walls and causes excess wear on parts when the engine starts
c. it causes the engine to burn too much fuel
d. it takes too much fuel from the carburetor

65. In order to stop an engine equipped with a Bendix Stromberg high-pressure carburetor,

a. move the throttle wide open at the same time you put the mixture control in idle cutoff
b. leave the throttle at about 800 r.p.m. and put the mixture control in idle cutoff
c. shut off the fuel and cut the magneto switch when the fuel pressure drops to zero
d. shut off the fuel and turn off the magneto switch after the engine stops firing

66. Fuel-cock controls in the cockpit should be set

a. so that the pointer lines up with a particular tank
b. so that the pointer is 10 deg. away from the tank setting
c. by the click-and-feel method
d. so that the pointer is 15 deg. away from the tank setting

67. Aircraft structure near the battery is protected against corrosion with

a. silver paint
b. acidproof paint
c. zinc primer
d. red lead

68. Oil tanks and oil coolers will be flushed with kerosene every

a. 100 hr.
b. 200 hr.
c. 300 hr.
d. engine change

69. If a coolant pump was leaking past the packing, you would

a. immediately replace the pump
b. tighten the packing nut first, to see whether that would stop the leak
c. replace the impeller in the pump
d. grease the pump

70. Before an engine is run faster than one-half its maximum permissible ground r.p.m., the oil pressure must be

a. at least 60 lb.
b. about 100 lb.
c. at least two-thirds of the normal minimum full-power oil pressure
d. at least 30 lb.

71. The magneto switch should be checked for proper functioning when turned to the Off position at

a. full throttle
b. two-thirds throttle
c. about 700 r.p.m.
d. cruising manifold pressure

72. Aluminum and aluminum-alloy tubing will be annealed

a. every 300 hr.
b. when it is made
c. every engine change
d. every 600 hr.

73. The color-band identification marks for Prestone lines are

a. black and white
b. black, white, and black

c. white, black, and white
d. white

74. When an engine equipped with Curtiss electric propeller is being started, it should be in
a. high pitch
b. low pitch
c. automatic
d. any position

75. The oil dilution valve should be operated at an engine speed of about
a. 1,750 r.p.m.
b. 550 r.p.m.
c. 1,000 r.p.m.
d. 800 r.p.m.

76. Each flexible hose connection from the engine scavenging pump to the oil cooler requires
a. four hose clamps
b. two hose clamps
c. six hose clamps
d. three hose clamps

77. In installing new mounting-ring grommets, the bolts, bushings, and washers will be coated lightly with
a. engine oil
b. castor oil
c. petrolatum
d. rust-preventive compound

78. On radial engines, excessive oil collection from the blower section can be checked, when the engine is being prepared for service, by removing
a. the lowermost intake pipes
b. the oil-sump plug
c. the Cuno strainer
d. the oil pressure relief valve

79. In starting an engine, the carburetor air heater should be placed
a. in the On position, to help vaporize the fuel

b. in the On position, to prevent icing in the carburetor
c. in the Off position, to prevent damage to the valve door resulting from backfire
d. in the On position, to obtain higher manifold pressures
e. in the On position, to heat the air going to the idle air bleed

80. The proper way to remove an intake pipe is to
a. loosen the packing nut at the supercharger section first, then the flange at the cylinder
b. loosen the cylinder end first
c. loosen both ends at the same time
d. loosen either end first

81. Which of the following systems would be used to register the r.p.m. of the two outboard engines in a four-engine plane?
a. chronometric tachometer
b. generator-voltmeter tachometer
c. magnetic tachometer
d. centrifugal tachometer

82. In checking valve clearances, the piston is placed
a. at TC compression stroke
b. at TC exhaust stroke
c. at BC suction stroke
d. at BC power stroke

83. In preparing an engine for shipment, the spark plugs
a. are left in the engine
b. are replaced with brass shipping plugs and packed separately, to accompany the engine
c. are replaced with corks
d. need not be specially considered

84. After the cooling system of a liquid-cooled engine has been drained, the ethylene glycol is
a. discarded
b. strained and saved for reuse
c. boiled, to remove impurities
d. returned to the stockroom

85. The advantage of the injector system over the carburetor is that

a. it eliminates spark-plug trouble
b. there is less danger of icing in the induction system
c. higher octane fuel may be used without danger
d. it is easier in starting
e. air may be heated without affecting the weight of the charge

86. In order to check a voltmeter on a preflight inspection for a reading of 14.25 volts

a. the main-line switch must be On and the engine running at idling speed
b. the main-line switch must be Off and the engine running at idling speed
c. the main-line switch must be Off and the engine running at cruising speed
d. the main-line switch must be On and the engine running at cruising speed

87. If excessive fuel was dripping from the overflow line of a fuel pump during engine operation, the likely defect is

a. a relief valve out of adjustment
b. a relief valve is sticking
c. punctured bellows in the sylphon-type relief valve
d. the packing may be worn, or the shaft may be worn or distorted

88. If the cork cone of the D-type fuel cock is binding,

a. the fuel cock will be replaced
b. the cock will be dismantled and the cork cone rubbed with castor oil and prepared graphite
c. the universals will be oiled
d. the universals will be replaced

89. When starting an engine equipped with a Hamilton hydromatic propeller you would start in

a. high pitch
b. low pitch

c. any position, as it would make no difference

d. automatic

90. When an engine equipped with a Bendix Stromberg pressure-type carburetor is being started, the mixture control should be in

a. Idle Cutoff position

b. Automatic Rich position

c. Full Rich position

d. Automatic Lean position

91. In starting a Holly pressure-type carburetor, the mixture control should be in

a. Idle Cutoff position

b. Full Rich position

c. any position, as it would make no difference

d. Full Lean condition

92. When an engine equipped with a float type of carburetor is being started, the mixture control should be in

a. Full Rich position

b. Full Lean

c. a position depending on the size of the engine

d. any position, as it would make no difference

93. On the ground warm-up of an engine, the slow-speed check should be taken at about 700 r.p.m.

a. to see that the magneto is functioning properly

b. to see if the magneto switch is operating properly

c. to check the condenser for proper operation

d. to see that there is the proper clearance in the points

94. When checking a two-speed supercharger on the ground run-up,

a. move the control from high blower to low blower, watching for a drop in manifold pressure

b. move the control from low blower to high blower, watching for a drop in manifold pressure

c. have the supercharger turned off

d. watch the supercharger tachometer

95. In checking the magneto for proper operation with the engine running at maximum ground r.p.m., the drop for one magneto should not exceed

a. 110 to 125 r.p.m.
b. 40 to 100 r.p.m.
c. 150 to 200 r.p.m.
d. an average of 150 for both magnetos

96. When checking a voltmeter with the engine speed approximately 1,500 r.p.m. with the main line switch off, you should get a reading of

a. 14.25 amp.
b. 16.3 volts
c. 14.25 volts
d. 12.2 volts

97. In starting an aircraft engine, the carburetor air heater

a. should be full hot
b. would depend upon the outside-air temperature
c. should be full cold
d. would depend on the size and type of the engine

98. The manifold pressure gauge vent line should be drained at

a. 2,100 r.p.m.
b. maximum ground r.p.m.
c. idling speeds
d. about 1,200 r.p.m.

99. When starting a hot engine, you would

a. prime approximately six or seven times
b. not find it advisable to use prime
c. would depend on the size of the engine and the length of the primer lines
d. depend largely on the diameter of the cylinders

100. In starting a twin-engine airplane, the cross-feed valve should be in

a. the On position
b. the neutral position
c. the Off position

d. a position depending upon the construction of the gas system

ESSAY-TYPE QUESTIONS*

101. What system has been developed to prevent a low cranking torque during cold weather?

102. What indicates the fact that fuel is being supplied to the carburetor?

103. How may an engine be checked for compression?

104. Why should high-speed operation of an aircraft engine be limited to short bursts during ground operation?

105. During hot weather, why should high-performance engines be stopped as soon as possible after landing?

106. When are aircraft engines usually subjected to highest operating temperatures?

107. How should an airplane engine be stopped that is not equipped with an idle cutoff?

108. How should engines equipped with an idle cutoff be stopped?

109. During the warm-up period, at what speed should the engine be operated until the oil pressure and oil temperatures become normal?

110. In starting an aircraft engine, how may overpriming be remedied?

111. What results from the overpriming of an engine?

112. What factors determine the total number of strokes required to prime an engine for starting?

113. Why should the heat control be placed in a Cold position in starting an engine?

114. Does pumping the throttle on a float-type carburetor aid in starting an airplane engine? Explain.

115. Where should the throttle be placed when an aircraft engine is being started?

* Answers are given on p. 214.

116. Should the operator vigorously operate the wobble pump before starting an engine? Explain.

117. How would you start an airplane engine equipped with a Bendix Stromberg pressure-type carburetor?

118. How may the formation of ice in the carburetor be recognized?

119. What is the purpose of a fuel-air ratio indicator installed in the aircraft cockpit?

120. Assuming that you have no fuel-air ratio indicator, or fuel-flow meter, how may you obtain lean best power using the mixture control?

121. Where should the mixture control be set for take-off, climb, or landing?

122. With the mixture and the throttle control unchanged, will the mixture be enriched as high altitudes are attained?

123. How may rich best power be obtained by the use of the mixture control, assuming that you have no fuel-flow meter or fuel-air ratio indicator?

124. Why should sudden acceleration and deacceleration of the throttle be avoided?

125. *a.* What instrument indicates the crankshaft speed of the engine?

b. What instrument indicates head temperatures?

c. What instrument indicates oil temperatures?

126. With all existing conditions normal, which has the greater effect on engine temperatures, mixture control or the oil shutter control?

127. Will the use of the carburetor air heater increase engine temperatures?

128. What is the purpose of the carburetor air heater?

129. Should highly supercharged engines be operated at full throttle during low-altitude operation? Explain.

130. Are supercharger controls marked?

131. How are mixture controls marked?

132. Why are adjustable throttle stops installed on some types of throttle controls?

133. Name the various engine controls used in modern aircraft.

134. Why is the fuel cock never shut off on an aircraft engine equipped with a fuel injector?

135. Differentiate between a preheater and a hot spot.

136. What is the reason for starting a Hamilton hydromatic propeller in low-pitch high-r.p.m. position?

137. Why is it a good practice to drain oil at regular intervals?

138. On a preflight inspection, how is the ignition switch tested for the Off position?

139. What is an aircraft battery inspected for?

140. How can an eccentric commutator on a generator be detected?

141. What is the proper torque for installing spark plugs?

142. Why is it important first to turn over the propeller by hand before starting an aircraft engine?

143. When an inferior grade of fuel is used, what precaution must be taken in operating an engine?

144. What is the most effective way to keep an aircraft fuel system free of water?

145. If a Parker primer pump were to leak around the handle of the pump, what would be your first corrective step?

146. What is done to an aircraft clock on the preflight inspection?

147. While operating an engine the detonation tendencies may be reduced. List four methods by which this can be done.

148. How would you eliminate the fluctuation of an oil pressure gauge in cold weather?

149. By what means are air-cooled engine temperatures indicated?

150. What two instruments indicate the throttle-control position?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 193

1. *b*	2. *c*	3. *d*	4. *b*	5. *b*	6. *a*
7. *d*	8. *d*	9. *a*	10. *b*	11. *c*	12. *a*
13. *b*	14. *a*	15. *b*	16. *d*	17. *c*	18. *a*
19. *b*	20. *c*	21. *b*	22. *c*	23. *d*	24. *d*
25. *c*	26. *c*	27. *d*	28. *c*	29. *c*	30. *b*
31. *c*	32. *b*	33. *d*	34. *c*	35. *b*	36. *b*
37. *a*	38. *c*	39. *d*	40. *d*	41. *d*	42. *b*
43. *d*	44. *c*	45. *c*	46. *c*	47. *c*	48. *d*
49. *a*	50. *c*	51. *d*	52. *d*	53. *a*	54. *a*
55. *a*	56. *b*	57. *b*	58. *b*	59. *d*	60. *e*
61. *d*	62. *c*	63. *a*	64. *b*	65. *b*	66. *c*
67. *b*	68. *d*	69. *b*	70. *c*	71. *c*	72. *b*
73. *c*	74. *b*	75. *d*	76. *a*	77. *b*	78. *a*
79. *c*	80. *a*	81. *a*	82. *a*	83. *b*	84. *b*
85. *b*	86. *c*	87. *d*	88. *b*	89. *b*	90. *a*
91. *b*	92. *a*	93. *b*	94. *a*	95. *b*	96. *c*
97. *c*	98. *c*	99. *b*	100. *c*		

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 212

101. An oil dilution system. Owing to the difficulties experienced in starting aircraft engines in cold weather, an oil dilution system has been developed to dilute the oil immediately before the engine is stopped, when a cold start is anticipated. The high cranking torque of a cold engine is due largely to viscous drag of the oil, particularly between the pistons and the cylinder walls. Therefore, it would be evident that a decided thinning of the oil immediately before the engine is stopped will greatly reduce the cranking torque and facilitate subsequent starting. This system will always have incorporated the main oil supply tank, a hopper tank.

102. The fuel pressure gauge. By the operation of the hand wobble pump the fuel will by-pass the engine pump supplying fuel to the carburetor. Inasmuch as the fuel pressure gauge line is tapped into the carburetor, any pressure in the carburetor will be readily noted on the fuel pressure gauge.

103. (*a*) By pulling the propeller through by hand. (*b*) By a suitable compression gauge, inserted in the front spark-plug hole.

104. To prevent excessively high cylinder or oil temperatures, as highly baffled aircraft engines depend largely on the forward motion of the airplane through the air for cooling.

105. To assist in keeping down the temperatures.

106. During ground engine check, take-off, and climb.

107. Various methods are employed in stopping aircraft engines. All specific instructions should be adhered to for the particular equipment involved. The following procedure applies to airplanes equipped with force-feed fuel systems, and brakes, low-performance engines not susceptible to afterfiring when the ignition switch is off, and engines not equipped with fuel injectors or carburetors with idle cutoff features.

a. Set the mixture control at full rich.

b. Close the fuel valve.

c. Close the throttle to normal idling position and allow to run at normal idling speed for a few minutes, with cowling flaps or radiator shutters fully opened, until the fuel pressure has dropped to zero.

d. Open the throttle slowly until the engine reaches a speed of between 800 and 1,000 r.p.m. and cut the ignition switch. Then, with the ignition switch off, slowly move the throttle to a Full Open position.

e. When the engine has stopped, turn the fuel valve to the "On" position and operate the wobble pump until an indication of pressure is shown on the fuel pressure gauge. Then shut off the fuel.

f. Allow the throttle to remain in its Open position after stopping the engine, as this lessens the likelihood of accidental starting while the engine is hot.

108. Engines equipped with carburetors having an idle cutoff are stopped without closing the fuel valve, by first

idling at between 600 and 800 r.p.m. and then setting the mixture control lever to Full Lean position. This actuates the idling cutoff valve, which causes the engine to cut out rather abruptly. The ignition switch should then be turned to the Off position after the engine ceases firing; since the carburetor is not drained, the mixture control lever is left in a Full Lean position as a precaution against accidental starting. In stopping these engines, the throttle should not be opened, because this will force a charge of fuel into the engine cylinders.

109. At a speed not to exceed one-half of the permissible maximum ground speed.

110. By opening the throttle to the wide-open position and turning the engine over four or five times by hand. (Make sure that the ignition switch is off.)

111. Loss of compression and exposing of parts to excessive wear resulting from insufficient lubrication.

112. The size of the engine, the length of the primer lines, and the temperature of the engine.

113. Because possible backfire may do damage to the heat control valve or the induction system.

114. No, as it may cause the accelerating pump to flood the carburetor and present a fire hazard.

115. In a position to prevent an engine speed of approximately 600 r.p.m. Usually this can be obtained by a throttle opening of about one-tenth.

116. No, it may cause flooding of the carburetor and present a fire hazard in case of a backfire.

117. *a.* Turn on the fuel and set the throttle between 800 and 900 r.p.m.

b. Place the mixture control in Idle Cutoff position.

c. With a hand pump build up a pressure of from 14 to 16 lb.

d. Prime the engine.

e. Engage the starter; then, after the engine has turned one or two revolutions, place the ignition switch to On. As soon as the engine fires, move mixture control from the

Idle Cutoff position to the Automatic Rich position. Set the throttle between 900 and 1,000 r.p.m. for warm-up.

118. By a gradual loss of r.p.m. and manifold pressure without changing of throttle or flight attitude.

119. To eliminate guesswork in obtaining the desired mixture control setting at any condition of engine operation. It indicates the air-to-fuel ratio.

120. By moving the mixture control from rich best power toward a leaner position and stopping movement just before there is a reduction of r.p.m. on the tachometer.

121. At Full Rich position.

122. Yes. Because the atmosphere becomes less dense at high altitudes.

123. By moving the mixture control from full rich toward a leaner position until the maximum r.p.m. is noted.

124. Because it decreases the life and reliability of the engine.

125. (*a*) Tachometer, (*b*) Head temperature gauge (Coolant temperature, if it is in a liquid-cooled engine), (*c*) Oil temperature gauge.

126. Mixture control. It is always to be remembered that a rich mixture will give you a cooler running engine and lean mixtures will raise the engine temperatures.

127. Yes. Carburetor air heaters are very sensitive in raising the carburetor air temperatures; therefore, in increasing the engine temperatures.

128. To assist in vaporization of the fuel charge and to prevent ice formation in the carburetor.

129. No. It may cause serious engine damage resulting from detonation and overheating.

130. Yes. They are usually marked with the letter *b* and the control quadrant is marked Off and On.

131. Usually with the letter *M*. The quadrant is marked Lean and Rich.

132. To warn the pilot to limit the opening of the throttle to below the critical altitude of the engines on highly supercharged engines.

133. (*a*) Throttle, (*b*) mixture, (*c*) carburetor air heat, (*d*) supercharger, (*e*) radiator or cowling shutters, (*f*) propeller control.

134. The fuel cock is never shut off except in an emergency. This keeps the fuel lines from the injector to the discharge nozzle filled with fuel and avoids undue cranking or delayed starting for subsequent operation.

135. A preheater is a device that warms the air before it reaches the carburetor, thus preventing icing conditions. A hot spot heats the air after it goes through the carburetor, thus aiding in better vaporization of the fuel.

136. To reduce load on the engine, thus improving the cooling.

137. Because of the accumulation of heavy ends of gasoline and acids, which are not removed by filters.

138. With the engine running at approximately one-third throttle or about 700 r.p.m., turn the switch momentarily to the Off position. If the engine does not cease to fire, you will know that the switch is not grounding out the magnetos.

139. It is inspected for leakage of acid resulting from cracks in the case or from defective sealing compound. Test all cells for specific gravity reading; the battery terminals for condition, security of mountings, the general condition of the battery, and the battery vent system.

140. Hold the end of a pencil on top of the brush, with the generator operating. If the point vibrates noticeably, the commutator needs refacing.

141. 480 in.-lb. or 40 ft.-lb.

142. To ensure that the combustion chambers are cleared of all oil. If the engine is started with oil or gasoline in the cylinders, cylinder heads, pistons, and rods may be damaged.

143. You should operate but not exceed cruising manifold pressures, to avoid detonation.

144. Keep the tanks full at all times, with frequent draining of the sumps.

145. Tighten the packing nut gland.

146. Wind the clock and set it, making sure that you do not overwind it.

147. (*a*) Reduce the throttle setting. (*b*) Use a richer mixture. (*c*) Reduce the manifold pressure. (*d*) Avoid long warm-up periods.

148. Disconnect the line at the gauge and engine pressure side of the line. Then connect the line to the pressure gauge and fill the line from the bottom with a light instrument oil. Then connect the line back to the engine, run the engine, and watch the oil pressure gauge.

149. (*a*) By the cylinder-head temperature gauge, (*b*) by the oil temperature gauge, (*c*) by the carburetor air-intake temperature gauge.

150. The manifold pressure gauge and the tachometer.

CHAPTER VIII

COOLING SYSTEMS

Function and Methods.—On modern engines, combustion temperatures reach the neighborhood of 4500°F. This is above the melting points of the metals used, and the heat must be dissipated to prevent the engine from burning out. The function of the cooling system is to keep engine temperatures within safe limits. Engines are cooled directly (air cooled) or indirectly (liquid cooled). In either instance, the rate of flow of the air cools the engine. Air-cooled engines employ cooling fins to dissipate heat. Liquid-cooled engines use Prestone (ethylene glycol) to transfer the heat from the engine to the air-cooled radiator.

The rate of cooling depends upon, among other things, the thermal conductivity of the metals used, the rate of air flow, atmospheric temperature, etc. As a general rule, the hotter an engine can operate, the better its thermal efficiency. When less heat is lost in cooling, more heat can be utilized for power.

Devices for Cooling.—To ensure more positive cooling, modern radial engines incorporate pressure baffles, or air deflectors, to speed up the air flow around the cylinders. An attendant disadvantage, however, is that the baffles tend to cause overheating on ground operation. To aid in cooling, some propellers have cuffs, or extensions, on the blades to direct an air blast over the engine. Streamlined, ring-type cowling assists in proper cooling. The problem is to keep head resistance to a minimum and, at the same time, provide adequate cooling efficiency.

Engine Heat Cooled by Lubricating Oil.—Average cylinder-head temperatures of air-cooled engines run in the neighbor-

hood of 200°C.; Prestone-cooled engines, about 150°C. A considerable amount of heat is conducted from the engine by its lubricating oil. Of the effective cooling necessary, approximately 30 per cent is done by the lubricating oil on most large engines. Any abnormal oil-temperature condition will reflect in the engine-operating temperature.

Liquid-cooled engines use jacketed cylinders, expansion tanks, circulating pumps, and radiators. Radiator shutters and centrifuge tanks also are employed. The function of the centrifuge tank is to separate gases and vapors from the coolant.

Airplanes should be placed facing the wind, when possible, during ground operation, to receive the cooling due to the increased air flow.

Construction Problems.—The cooling problem on large airplane engines is one of its limiting construction factors. More heat has to be dissipated in some of the larger engines than in a locomotive engine. Among other considerations, the strength of most metals falls off rapidly when extreme temperatures are encountered.

Modern air-cooled engines have forged cylinder heads, the better to withstand the higher pressures and temperatures encountered. The fin area has been increased, and constant research is endeavoring to increase cooling efficiencies.

MULTIPLE-CHOICE QUESTIONS*

1. The capacity of a cooling system for an aircraft engine shall be

a. 1 gal. for each 75 hp.
b. 1 gal. for each 20 gal. of fuel carried
c. twice as much as the engine will need at take-off hp.
d. sufficient to maintain safe operating temperatures under all conditions of flight
e. as specified in CAR

* A key to the answers is given on p. 232.

2. An advantage of water over ethylene glycol as a coolant is that

a. it is purer
b. it has a high freezing point
c. it has a lower boiling point
d. it is more readily available and has a higher specific heat value
e. it has a higher boiling point

3. The operating temperature of a water-cooled engine should be about

a. 180°F.
b. 210°F.
c. 280°F.
d. 140°F.
e. 300°F.

4. A centrifuge, as used in a liquid cooling system, is to

a. remove any dirt or rust from the coolant
b. prevent high pressures in the system
c. prevent boiling at high altitudes
d. remove gases and vapors from the coolant
e. improve the cooling

5. A modern cooling system is sealed, to

a. maintain a high boiling point at high altitudes
b. prevent loss of coolant
c. maintain more even temperatures
d. reduce the amount of coolant needed, and so the weight

6. A relief valve is used in the expansion tank of a cooling system to

a. allow air to enter the tank when the liquid cools
b. allow the pressure to be relieved from the tank when the coolant expands
c. maintain proper pump pressures
d. control the temperature of the coolant
e. remove any gases from the coolant

7. The operating temperature of an ethylene glycol-cooled engine should be about

a. 180°F.
b. 212°F.
c. 378°F.
d. 280°F.
e. 140°F.

8. The centrifugal type of water pump is used in cooling systems because
a. higher pressures can be built up
b. it requires the least care
c. it has a larger capacity for its size than other pumps have
d. it is easier to connect to two banks of cylinders
e. it is the simplest type

9. An advantage of the liquid-cooled engine over the air-cooled engine is that it
a. is easier to streamline
b. is lighter per horsepower
c. is more economical
d. has less trouble with the cooling system
e. runs much cooler

10. An advantage of an air-cooled system over a liquid-cooled system is that it
a. is lighter per horsepower
b. is easier to streamline
c. is easier to control cooling
d. runs cooler in hot climates
e. operates at more even temperatures

11. Engine temperature is controlled on a liquid-cooled engine by
a. pressure baffles
b. an oil temperature regulator
c. a thermocouple on the cylinder containing the master rod
d. an oil temperature regulator
e. radiator shutters

12. Maximum operating temperature for an ethylene glycol-cooled engine is
a. 60°C.

b. 85°C.
c. 150°C.
d. 160°F.

13. Air deflectors or pressure baffles are used to
a. increase air flow around cylinders
b. deflect air from spark plugs
c. increase air pressure to the carburetor
d. control flow of air through the oil temperature regulator

14. One of the disadvantages of ethylene glycol is that it
a. freezes at 0°F.
b. has low specific heat
c. requires the use of a larger radiator
d. gums up the cooling system

15. How are ethylene glycol lines identified?
a. by a black line between two white lines
b. by a white line between two black lines
c. by a light-blue line and a green line
d. by a dark-green line

16. What connections do you find on an expansion tank?
a. inlet from engine, outlet to radiator, drain
b. inlet from engine, outlet to radiator, vent
c. inlet from radiator, outlet to engine, vent
d. inlet from pump, outlet to engine, drain

17. One of the disadvantages of glycerine as a coolant is that it
a. has high specific heat
b. has a low boiling point
c. gums up the cooling system
d. has a low freezing point

18. Engine-operating temperature is taken on an air-cooled engine by a
a. thermometer on the head
b. thermocouple on the cylinder
c. thermometer on the sump
d. thermocouple in the oil sump

19. The purpose of the thermostat on the cooling system of a liquid-cooled engine is to

a. operate radiator shutters
b. control the flow of coolant
c. operate the signal on the instrument board
d. indicate the temperature of the coolant

20. New-type air-cooled cylinders have

a. heavier heads
b. more cooling fins
c. larger exhaust valves
d. fewer cooling fins

21. What is the purpose of a centrifuge tank?

a. to cool the hot coolant
b. to serve as a reservoir for the coolant
c. to separate gas vapors
d. to separate any solid particles from the coolant

22. How is engine temperature controlled on an air-cooled engine?

a. by pressure baffles
b. by an oil temperature regulator
c. by controllable flaps
d. by the use of ring cowling

23. One of the disadvantages of alcohol as a coolant is that it

a. has high specific heat
b. has a low boiling point
c. gums up the cooling system
d. has a low freezing point

24. How are water lines identified?

a. by a black line
b. by a white line
c. by a light-blue line
d. by a dark-green line

25. The coolant pump is located between the

a. centrifuge tank and the engine
b. radiator and the engine

c. centrifuge tank and the radiator
d. expansion tank and the engine

26. After filling a cooling system, why drain off a gallon?
a. to check for leaks
b. the cooling system is oversize
c. to allow for the capacity of the centrifuge tank
d. to allow room for expansion

27. Ground operation of an air-cooled engine is limited by
a. possibility of overspeeding the engine
b. insufficient cooling
c. the fact that the oil does not return properly to the sump
d. overheating of the pressure baffles

28. In liquid-cooled engines, the coolant flows in at
a. the front of the engine and out at the back
b. the back of the engine and out at the front
c. the top of the engine and out at the bottom
d. the bottom of the engine and out at the top

29. The most important advantage of ethylene glycol as a coolant is that it
a. has a high boiling point
b. has low specific heat
c. has a high rate of flow
d. is incombustible

30. About what is the maximum operating temperature for an air-cooled engine, when it is taken on the cylinder head?
a. 85°C.
b. 150°C.
c. 280°C.
d. 350°C.

31. The cylinder head on a liquid-cooled engine
a. may be removed by parting at the coolant jacket
b. may be removed by parting at the crankcase
c. is not removable
d. may be removed by heating it with a blow torch and tapping it loose

32. What instrument is used to test the strength of the ethylene glycol?

a. thermohydrometer
b. thermometer
c. thermocouple
d. hydrometer

33. What is the color of ethylene glycol?

a. blue
b. light-green
c. red
d. colorless

34. What is the purpose of the relief valves on the expansion tank?

a. to by-pass coolant if the centrifuge tank plugs up
b. to relieve excess coolant pressure at high speed
c. to equalize pressure between the radiator and the expansion tank
d. to maintain a constant differential air pressure in the system

35. The use of ethylene glycol for cooling an engine permits

a. the engine to operate cooler
b. lower operating temperatures
c. higher engine speeds
d. higher operating temperatures

36. What per cent of the combustion heat is removed by the cooling system?

a. 7 per cent
b. 30 per cent
c. 65 per cent
d. 90 per cent

37. What is a thermocouple?

a. a device for measuring heat
b. a device for measuring speed
c. a device for measuring pressure
d. a device for measuring the rate of climb

38. When running up an airplane engine, you would

a. place the airplane cross-wind

b. place the airplane so that the wind is blowing on the tail, thus helping to hold the tail down

c. place the airplane into the wind

d. on an exceptionally windy day, run the airplane up in the hangar

39. Too low an oil content would cause

a. the engine to run too cool

b. high oil temperatures

c. detonation

d. the hot spot to work inefficiently

40. A clogged oil radiator would cause

a. insufficient lubrication on account of the restriction

b. insufficient lubrication on account of the gases that would build up in the cooler

c. the oil to have a low boiling point at high altitudes

d. high oil temperatures on account of insufficient cooling

41. A rich mixture would

a. cause the engine to overheat

b. cause detonation

c. cause the engine to backfire

d. help cool the engine

42. Intake valves are cooled by

a. potassium dichromite crystals in the valve stem

b. having the intake valve made of a higher grade of steel, therefore dissipating heat better

c. metallic sodium

d. the incoming fuel charge

43. In shutting down an aircraft engine, afterfiring may be caused by

a. too low head temperatures

b. too lean a mixture

c. too rich a mixture

d. too hot an engine

44. Cylinder temperatures are regulated by

a. mixture control-cowl flaps-throttle setting
b. oil shutter valve-wing flaps-coolant pump
c. skillful elimination of friction horsepower
d. automatic cow-flap control

45. Before an aircraft engine is shut down, the cylinder-head temperatures should be below

a. 260°C.
b. 300°C.
c. 105°C.
d. 75°C.

46. The only time an engine can be cooled by leaning out the mixture is

a. in high speed cruising
b. at rated power
c. at maximum power
d. in best economy operation

47. Why are radiator shutters incorporated in a liquid-cooled engine?

a. they are required by the CAA
b. they are required only in engines up to 1,300 hp.
c. for better cooling control
d. to keep dust and foreign matter out of the radiator core while the airplane is idle

48. Before the ground testing of an aircraft engine, the minimum oil in temperature should be about

a. 20°C.
b. 88°C.
c. 40°C.
d. it makes no difference, as long as you have pressure showing on the oil pressure gauge

49. To cool an aircraft engine in a climb, you would

a. use a leaner mixture
b. climb at a faster air speed
c. close the carburetor air heater
d. climb at an increased r.p.m.

50. You would determine the coolant temperatures on a liquid-cooled engine by

a. a coolant flow meter
b. a coolant temperature gauge
c. use of a thermocouple and gauge
d. use of a suitable head-temperature gauge

ESSAY-TYPE QUESTIONS*

51. What is employed on radial air-cooled engines to determine the cylinder-head temperature?

52. Where is instrument that is the answer to the above question placed, and why?

53. Should the wires from a thermocouple ever be shortened or lengthened? Why?

54. What is the purpose of two valves installed in the filler unit of the expansion tank of a liquid-cooled system?

55. List five things that you would inspect on a 50 hr. inspection of a liquid cooling system.

56. Why is it undesirable to overfill a Prestone cooling system?

57. What would happen if scale had collected and settled in a coolant radiator?

58. What would you do in cold weather if you noticed a laggy reading on the oil pressure gauge after starting the engine?

59. How would you fill an oil pressure gauge line with instrument oil?

60. When is the oil dilution valve operated?

61. Is it necessary to use a hose liner when making a flexible-hose-type connection on aluminum fuel lines?

62. Why should you never take off with a cold engine?

63. In starting an engine equipped with a Curtiss electric propeller, why is it necessary to have the blade angle in low pitch, high r.p.m.?

* Answers are given on p. 232.

64. Are coolant radiators bonded? Do oil coolers require bonding? Do surge chambers and expansion tanks require bonding?

65. Explain why pistons are constructed of a light aluminum alloy.

66. How does oil cool an engine?

67. Explain how the forward motion of an airplane helps cool an engine.

68. Why must you not exceed high manifold pressures and high r.p.m. on a ground run-up? Explain.

69. Explain the function of the thermostatic valve incorporated in an oil cooler.

70. Why must the engine cowl flaps always be open on ground run-up?

71. In cold-weather operation, what is the advantage of an oil dilution system?

72. In an engine incorporating a two-stage supercharger, or a turbosupercharger, why is it necessary to have inter-coolers?

73. What is the purpose of a preheater? of the hot spot?

74. Name three ways in which the cylinder-head temperature of an engine could be raised?

75. Why is it essential that the operating temperatures of the engine be maintained within safe limits?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 222

1. *d*	2. *d*	3. *a*	4. *d*	5. *a*	6. *b*
7. *d*	8. *c*	9. *a*	10. *a*	11. *c*	12. *c*
13. *a*	14. *b*	15. *a*	16. *b*	17. *c*	18. *b*
19. *a*	20. *b*	21. *c*	22. *c*	23. *b*	24. *b*
25. *b*	26. *d*	27. *b*	28. *d*	29. *a*	30. *c*
31. *c*	32. *a*	33. *d*	34. *d*	35. *d*	36. *b*
37. *a*	38. *c*	39. *b*	40. *d*	41. *d*	42. *d*
43. *d*	44. *a*	45. *c*	46. *d*	47. *c*	48. *c*
49. *b*	50. *b*				

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 231

51. A thermocouple and a cylinder-head temperature gauge are employed on radial air-cooled engines to determine the cylinder-head temperatures.

52. The thermocouple is usually installed in place of a standard spark-plug gasket on the rear spark plug of the master-rod cylinder, because it is the hottest running cylinder.

53. The wires of a thermocouple should never be shortened or lengthened. To do so would change the electrical resistance of the thermocouple wires and give an inaccurate gauge reading.

54. The purpose of two valves installed in the filler unit of the expansion tank of a liquid-cooled system is to maintain a constant differential pressure within the expansion tank.

55. Five things that you would check on a liquid cooling system on a 50-hr. inspection are the following: (*a*) inspect the radiator for leaks and security of mounting; (*b*) check hose clamps and flexible connections for tightness; (*c*) inspect the coolant pump for leaks at the packing gland; (*d*) check all lines for anchorage, wear, and proper color identification; (*e*) inspect the expansion tank for leaks and security of mountings.

56. It is undesirable to overfill a Prestone cooling system because the extra Prestone would escape through the overflow the first time the poppet valve opened to expel the gases.

57. If scale had collected and settled in the coolant radiator, it would decrease the cooling efficiency of the radiator and would interfere with the proper circulation of the coolant. Therefore, the engine would overheat.

58. The remedy for a laggy oil pressure gauge reading would be to fill the oil pressure gauge line with instrument oil.

59. You would fill an oil pressure gauge line by disconnecting both ends of the line. You would blow the line clean with compressed air, connect the line at the engine end, then fill the line with a light instrument oil, making sure that no oil was lost out of the line.

60. The oil dilution valve is operated for about 4 or 5 min. of engine operation after the last flight of the day when a cold start is anticipated.

61. The only time it is necessary to use a hose liner is when you do not use fuel- and oil-resistant hose. A liner is not necessary when fuel- and oil-resistant hose is used.

62. You should never take off with a cold engine, as the engine is liable to backfire because of too-lean mixtures. This would be caused by poor vaporization of the fuel.

63. You would start an engine equipped with a Curtiss electric propeller in the low pitch, high r.p.m., to reduce cranking torque and therefore afford better cooling.

64. Oil coolant radiators do not require bonding. Coolant radiators require bonding. Surge chambers and expansion tanks do not require bonding.

65. Pistons are constructed of a light aluminum alloy because a light aluminum alloy reduces operating stresses to a minimum and permits a very rapid conduction of heat away from the piston head to the adjoining engine parts for radiation. This results in comparatively low piston-operating temperatures.

66. Oil cools an engine by acting as a conductor and carrying the heat away. This is sometimes called a *thermobridge.*

67. An air-cooled engine depends on the forward motion and speed of the plane to help cool the engine. Therefore, the greater the volume of air passing by the cylinders, the cooler the engine will run.

68. You should never exceed high manifold pressures or high r.p.m. on the ground run-up, because the cooling factors are inadequate. If the high manifold pressures or high r.p.m. are exceeded, you can expect high cylinder temperatures which will cause detonation and result in possible mechanical failure.

69. When the oil scavenged from the engine is comparatively cool, the thermostatic valve is open, permitting the oil to flow around the core jacket to the top of the supply tank without flowing through the core. When the oil reaches a normal temperature, the thermostatic valve closes and directs the oil through the core for cooling purposes.

70. The engine cowl flaps should always be open on the ground run-up, to help cool the engine.

71. The advantage of the oil dilution system is that you can lower the viscosity of the oil in the hopper tank and the engine to reduce cranking torque. Another advantage is that the oil only has to be changed at engine change.

72. It is necessary to incorporate intercoolers, when using a turbosupercharger or a two-stage supercharger, to reduce the air temperature entering the carburetor.

73. The purpose of a preheater is to heat the air before it enters the carburetor, thereby eliminating ice. A hot spot heats the fuel-and-air mixture after it leaves the carburetor, thereby aiding in better vaporization of the fuel mixture.

74. Three ways of raising the cylinder-head temperature would be (*a*) raising the manifold pressure, (*b*) using a leaner mixture, (*c*) closing the cowl flaps.

75. It is essential that the operating temperatures of the engine shall be maintained within safe limits to prevent preignition, valve warpage, spark-plug failure, detonation, and other attendant disadvantages of a hot engine.

CHAPTER IX

PROPELLERS

The function of a propeller is to convert the brake horsepower into thrust. This thrust propels the plane through the air. Essentially, a propeller is an air-foil section, the lift being horizontal instead of vertical. The blade angle is greater near the hub and lesser toward the tip because of the different velocities of the sections of the blades.

Definitions.—Propeller terms are explained in the following definitions:

Blade angle—the angle between the chord of a blade section and a plane perpendicular to the axis of rotation. A change of 1 deg. in blade angle will affect engine r.p.m. between 70 to 100 r.p.m. (direct-drive engines).

Blade face—the flat side of a blade.

Blade back—the cambered side of a blade.

Blade root—the portion located in the hub.

Pitch (geometrical)—the distance the propeller would move through a solid medium in one revolution.

Effective pitch—the distance the propeller actually moves in one revolution in the air.

Slip—the difference between pitch and effective pitch.

Types.—The types of propellers include (1) the fixed-pitch types—limited to small engines; (2) the adjustable-pitch types, in which the pitch may be changed on the ground—also known as *ground adjustable* propellers; (3) controllable-pitch propellers—permitting change of the blade angle while in flight; (4) full-feathering and constant-speed types, for maximum propeller performance and efficiency.

The outstanding disadvantage of fixed-pitch propellers is that they do not permit the engine to attain full rated horsepower at take-off, when it is most needed.

Controllable types allow full rated horsepower by permitting the pitch to be set to a point that allows full engine r.p.m. These propellers are very effective at altitude, the blade angle being adjustable for changes in air density.

Constant-speed propellers function to keep the engine at a speed that is most efficient while, at the same time, allowing blade angle and airplane speed to adjust themselves to the varying conditions of flight.

Full-feathering propellers function to permit the stopping of the engine while in flight, by turning the blades parallel to the line of flight. In case of engine failure, the windmilling action of the propeller is prevented by feathering. Some large flying boats, such as Consolidated PB-2Y3, have reversible propellers for better maneuvering when water-borne.

Mountings.—Two types of mountings are in general use: (1) tapered crankshaft ends, using a key, which are found on small engines only; (2) splined crankshaft ends, or splined propeller drive shaft, in reduction-geared engines.

Most propeller-retaining nuts act as a puller when removing the prop. Suitable lock nuts or pins are provided.

Tapered propeller hubs seat directly on the tapered crankshaft. Splined hubs seat on front and rear cones. The rear cone uses a rear-cone spacer. Most spline shafts have one large or master spline. This wide spline aligns with the No. 1 blade of the propeller.

Cones and spacers, retaining nuts, lock nuts, snap rings, etc., are considered parts of the engine, not of the propeller.

Controllable-pitch propellers are of three types: (1) mechanical, (2) hydraulic, (3) electrical. Mechanical types use a series of gears within the hub and a stationary worm mounted on the engine. A high gear ratio is employed and a solenoid switch engages the mechanism. A pitch indicator on the instrument panel indicates the propeller angle.

HYDRAULICALLY OPERATED PROPELLERS

Hydraulically operated propellers operate by hydraulic force built up by the engine oiling system. In these types, oil pressure is used to move the blades to the low-pitch position, and spring returns or centrifugal force acting on counterweights attached to the blade brackets return the blades to high-pitch position.

The Hamilton Standard controllable propeller and the Hamilton Standard constant-speed propeller are identical in operation (except for the manually operated control valve on the constant-speed propeller) by an automatic constant-speed control, which regulates the amount of oil entering or draining from the cylinder of the propeller.

These designs incorporate a booster pump, to raise the engine oil pressure to 180 to 200 lb. per sq. in. A relief valve regulates the pressure and returns excess oil to the pump. Variations of engine speed cause movement of the governor flyweights, which act to control the oil flow to and from the propeller cylinder. This action maintains a propeller pitch that results in constant engine r.p.m.

Prior to the starting of controllable- or constant-speed propellers, the control should be set in a high-pitch position and the engine run 1 min. in this position. This is to prevent possible engine lubricating-oil starvation while filling the propeller cylinder, until the engine has time to build up adequate oil pressure.

The Hamilton Hydromatic constant-speed and feathering propellers differ from the previous types mentioned, inasmuch as they do not use counterweights or springs. The piston is movable and the cylinder stationary. The other types employ a stationary piston and a movable cylinder. These propellers use various forces to change blade angles. These forces are as follows: (1) centrifugal twisting movement, present in all rotating propellers, which tends to move the blades to low pitch position; (2) engine oil pressure for low-

pitch position; (3) boosted engine oil pressure for high-pitch position; (4) auxiliary pressure system for feathering operations—400 lb. required for feathering and 600 for unfeathering.

ELECTRICALLY OPERATED CONSTANT-SPEED AND FEATHERING PROPELLERS

Propellers such as the Curtiss electric propeller employ electrical energy for propeller operation. An electric pitch-changing motor, mounted in the hub, controls the blade angle through a two-stage planetary reduction gear, which in turn drives a power bevel gear. This gear is meshed with mating bevel gears on each blade shank.

Constant-speed control is obtained by an engine-driven governor, which energizes the motor by cutting in electric currents to obtain various blade angles. The motor has two field windings, to obtain opposite direction when desired. The governor operates two separate electrical circuits. Any variation in engine speed will cause the governor to contact increase- or decrease-speed circuits, thereby maintaining constant engine speed by changes of blade angle.

A magnetic brake is employed to stop the rotating inertia of the motor and speed-reducer gears at the desired blade angle. Automatic cutout switches limit the blade-angle range for ordinary operation. A third cutout switch operates at the 90-deg. angle during feathering operations. Manual and automatic controls are provided. Toggle switches on the propeller control panel provide a means of selecting the desired control.

When operating in the automatic control, the propeller functions as a constant-speed propeller. A selected engine speed is maintained by the engine-driven governor. When operating in the manual control, the propeller functions as a fixed-pitch propeller. However, the blade angle may be varied by the increased-r.p.m. and decreased-r.p.m. switches.

On extended flights, in some cases these propellers are adjusted to required engine r.p.m. and manifold pressure, the

best setting of the mixture control obtained, and the propeller set in the manual position to save battery current and minimize wear on the control mechanism.

Full propeller information may be found by consulting the manufacturers' handbooks and bulletins. Modern propeller servicing has reached the stage of specialization.

MULTIPLE-CHOICE QUESTIONS*

1. A wooden propeller may be corrected for horizontal balance by

a. drilling holes in the metal tips
b. placing a piece of metal on one side
c. drilling a hole in the shank and adding lead wool to light blades
d. tinning metal tips with solder on the cambered side
e. tinning metal tips with solder on the face side

2. A scratch over ⅛ in. deep across the face of a wooden propeller

a. may be repaired by filling in with a mixture of fine sawdust and glue
b. may be repaired by filling in with an inlay in compliance with CAM 18
c. may be repaired by smoothing out to conform with the contour of the blade
d. may be repaired by varnishing and covering with metal plate
e. may not be repaired

3. A fixed-pitch metal propeller can be corrected for unbalance by

a. grinding and polishing metal from a noncritical part of the blade
b. cutting a slight amount from the tip of the heavy blade and contouring to the form of the blade
c. adding or removing lead wool at special balancing holes in the hub

* A key to the answers is given on p. 252.

d. tinning the cambered side of the light blade

e. drilling small holes in the tip of the light blade

4. If a fixed-pitch aluminum-alloy propeller is out of track, it

a. may be corrected by shimming up the hub

b. may not be repaired

c. may be sprung, while cold, in press until the proper track is obtained

d. must be returned to the factory, annealed, straightened, and reheat-treated

e. may be corrected by refacing the centering cone

5. The blades of an aluminum-alloy propeller are inspected for cracks by

a. etching with a 20 per cent solution of nitric acid, cleaning with water, then with a 20 per cent solution of caustic soda, again cleaning with water, and inspecting with a magnifying glass

b. following the procedure in (*a*) but using first a 20 per cent solution of caustic soda, then a 20 per cent solution of muriatic acid

c. magnaflux inspection

d. etching as in (*a*), but with 20 per cent caustic soda, then 20 per cent nitric acid

e. etching as in (*a*) but with 20 per cent caustic soda, then 50 per cent nitric acid

6. A small cut, with the grain of wood

a. may be repaired by filling in with a mixture of fine sawdust and hot glue

b. may be repaired by filling with an inlay

c. may be repaired by working glue into the bottom of the crack, then refinishing

d. may not be repaired

e. may be repaired by covering with $\frac{1}{16}$-in. metal plate, in accordance with CAA specifications

7. The small holes drilled in the metal tips of a wooden propeller are for

a. relief of moisture that is forced out to the tips by centrifugal force
b. balancing
c. lightening the tips
d. inspection of the tips
e. preventing cracks in the tips resulting from vibration

8. Index pins in controllable-pitch and constant-speed propellers are used to

a. maintain the proper "base-setting" angle between the blades and the counterweight brackets
b. obtain proper balance of the propeller
c. limit the distance between high- and low-pitch settings
d. safety the counterweight covers
e. safety the counterweight bearing shafts

9. The hydromatic differs from the constant-speed propeller in that

a. its piston is stationary instead of movable
b. its control is automatic
c. counterweights are used to bring the blades into high pitch instead of low pitch
d. engine oil pressure is used to bring the blades to high pitch instead of low pitch

10. The controllable-pitch propeller differs from the constant-speed propeller in that

a. it is more efficient
b. pitch change is obtained by the action of counterweights and oil pressure
c. the pitch is controllable by the pilot
d. the piston moves to operate the propeller
e. it is not full feathering

11. The function of the oilite shim plates is to

a. adjust the clearance between the flanges on the blades and bearing races to obtain the proper preload
b. prevent galling of the spider
c. lubricate the blade flanges and bearings

d. take the thrust load caused by the centrifugal force on the blades

e. space the counterweight bearing

12. If a hollow steel propeller blade has a crack $5/16$ in. long at the leading or trailing edge,

a. it may be repaired by a certificated repair station equipped to do that type of work

b. it may be repaired by any certificated mechanic or anyone under the supervision of a certificated mechanic, provided that proper equipment is used

c. it may not be repaired

d. temporary relief may be furnished by soldering and rebalancing

e. it may be repaired by manufacturer decision only

13. A trailing edge on a wooden propeller has a sliver about 1 in. long and $3/32$ in. deep.

a. it may be repaired by removing the sliver and filling the space with fine sawdust and glue

b. it may be returned to the manufacturer for repair

c. it may not be repaired

d. it may be repaired by removing sliver, sanding down the trailing edge, and balancing with solder

e. it may be repaired by removing the sliver and sanding down both trailing edges an equal amount

14. On a wooden blade with an 8-in. chord there is found a damaged portion $1/2$ in. deep by 2 in. long on the leading edge.

a. it may be repaired by fitting with an inlay, as shown in CAM 18

b. it may not be repaired

c. it may be repaired by filling with a mixture of fine sawdust and glue

d. it may be repaired by reforming the edge to remove the damaged portion

e. it may be repaired by working glue into the bottom of the damaged portion, drying, smoothing, and refinishing

15. To check for wear of splines in a propeller hub,

a. use a single-key not-go gauge 0.002 in., over the drawing size of splines

b. use a single-key not-go gauge 20 per cent over the manufacturer's drawing size

c. use a spline adapter and see if it fits too freely

d. make visual inspection to see if any ridges have worn in the splines

e. measure with a micrometer and compare the withdrawing size

16. Dovetail-type inlays

a. may be used on repairs at the leading edge outside of tipping

b. may be used on the leading-edge repairs inside of tipping

c. may be used in repairing the face or the back of blades to within 2 in. of tipping

d. may be used to repair large-sized hubs

e. may not be used

17. The propeller hub nut should be checked for tightness

a. daily

b. every 20 hr.

c. at each periodic inspection

d. before each flight

e. unless it is installed properly; then it need not be checked

18. The number of inlay repairs permitted on each blade is

a. one large and two medium, or four small inlays not too close together

b. any number, provided that the ends of the inlays do not overlap more than 25 per cent

c. one large, three medium, or four small, widely separated inlays

d. four small widely separated, two medium, or two large

e. never over three inlays per blade

19. A spring is used on the 20-deg. constant-speed propellers

a. because, owing to the length of travel and the angle of counterweight slots, they will not give full travel without spring
b. with a booster pump, to overcome higher oil pressure
c. to help operate the governor
d. to obtain quick action in case of an emergency
e. never

20. If the preload (tightness of blade) on a controllable pitch propeller is too great, it may be corrected by
a. adjusting the oilite shim plate
b. lubricating the oilite shim plate
c. using a heavier bronze laminated shim
d. reducing the thickness of the laminated shim
e. loosening the barrel bolts slightly

21. The hub nut on a constant-speed propeller should be tightened to
a. 180 ft.-lb.
b. 720 ft.-lb.
c. 200-lb. on a 5-ft. bar
d. 180 in.-lb.
e. 1,300 in.-lb.

22. The stop on a constant-speed control should be adjusted to
a. limit the maximum speed of the engine during take-off
b. limit the maximum pitch of the propeller during take-off
c. give the proper pitch and speed for cruising
d. place the index pins in the hole stamped with the base-setting number
e. give the best speed for climbing

23. The vertical unbalance of a controllable-pitch propeller may be corrected by
a. removing material from a noncritical portion of the blade
b. adding or removing lead wool in the eccentric balancing hole
c. adding or removing lead wool in the barrel bolts
d. altering weight in the concentric balancing hole

e. adding or removing balancing washers on the stud in the aluminum plug in the blade

24. Track on a wooden propeller

a. may be corrected by shimming up the rear side of the hub

b. may be corrected by adding washers on the bolts on one side of the hub

c. may be corrected by tightening the bolts on one side of the hub more than on the other

d. may be corrected by springing the blades in a press

e. may not be corrected

25. On the controllable- and constant-speed propellers, if oil leaks around the base of the cylinder and the barrel, it may be caused by

a. leaky cylinder-head gasket

b. leaky piston oil seal

c. worn or damaged spider grease retainers

d. too-high oil pressure

e. leaky inboard and outboard piston gaskets

26. The purpose of painting the blade faces of metal propellers black is

a. to fill in and cover small scratches caused by wear

b. to eliminate damage caused by small stones

c. to eliminate glare

d. to assure horizontal balance

27. To correct the track of a metal propeller, you would

a. trim the blade backs

b. bend the blades

c. trim the blade face

d. change the pitch of the blades

e. shim one blade

28. The proper procedure with a propeller having a loose hub in the boss is to

a. insert a sleeve in the boss

b. shim the boss of the propeller

c. install an oversized hub

d. discard the propeller

29. The stresses imposed on a propeller are greatest at the

a. tips
b. hubs
c. trailing edge
d. leading edge

30. The approximate oil pressure necessary to feather a propeller is

a. 150 lb. per sq. in.
b. 200 lb. per sq. in.
c. 400 lb. per sq. in.
d. 800 lb. per sq. in.

31. The approximate oil pressure necessary to unfeather a propeller is

a. 100 lb. per sq. in.
b. 400 lb. per sq. in.
c. 200 lb. per sq. in.
d. 600 lb. per sq. in.

32. To determine the balance of a wooden propeller, you must

a. remove all tipping
b. test for horizontal and vertical balance
c. reprofile one blade
d. insert lead wool in the root of the blade

33. You can renew oilite shim plates on a controllable propeller by

a. washing and soaking them in gasoline
b. baking them on a solution of graphite
c. soaking them in hot oil
d. sandblasting and soaking them in an acid solution

34. Binding counterweight bearings on a controllable-pitch propeller would cause

a. complete engine failure
b. overconsumption of oil
c. sluggishness when changing pitch
d. the propeller to run out of track

35. Vertical balance is obtained on an adjustable propeller by

a. tapering one tip to conform to the weight of the opposite tip
b. tinning the tips with solder
c. relocating the clamp rings
d. caulking with lead wool

36. An adjustable-pitch propeller is set at low pitch so as

a. to obtain more power for take-off
b. to prevent the geometric pitch from exceeding the effective pitch
c. to eliminate slipping caused by higher r.p.m.
d. to obtain a smoother plane of rotation

37. On an adjustable-pitch metal propeller, you would obtain horizontal balance by

a. relocating the clamp rings
b. refacing the blade
c. removing a slight bit of metal from one tip
d. adding lead wool to the light blade

38. One difference between the hydromatic full-feathering propeller, and the constant-speed or controllable propeller is

a. the constant-speed propellers have a greater range of pitch
b. hydromatic propellers have no counterweights
c. the hydromatic have fewer moving parts, therefore they are easier to service
d. the constant-speed or controllable propellers have no counterweights

39. The result of a broken r.p.m. spring may be that

a. the engine would lose r.p.m.
b. it would block off the oil passages
c. the speed of the engine would become irregular
d. it would be noticed only at maximum r.p.m.

40. Oilite shims are used to

a. prevent the index pins from binding
b. assure the propeller of even track

c. prevent galling

d. assist in lubricating the counterweight bearings

41. The reason for employing counterweights is

a. to increase the blade angle

b. to correct for vertical balance

c. to assure the index pins of proper seating

d. to maintain a longitudinal balance

42. On a controllable-pitch propeller, the low pitch is used

a. for cruising

b. to decrease r.p.m.

c. for take-off

d. for high forward speeds

43. To correct for elongated bolt holes in a wooden propeller, you would

a. return the propeller to the manufacturer for repairs

b. rebore it oversize, shim, and fit with larger bolts

c. discard the propeller

d. place washers behind the bolt head and tighten

44. What is known as *propeller flutter* is

a. the tendency of the propeller to run out of track

b. vibration at which the ends of the blades twist back and forth at high frequency

c. the tendency of the propeller to hunt or run off pitch at high speeds

d. the tendency of the hub to run out of true

45. The reason for a breather in the dome of some types of propellers is

a. to prevent pressure from building up in the crankcase

b. to prevent a rapid rate or surge of oil when feathering

c. to control the oil temperature in the dome

d. to assist in more rapid cooling of the nose section of the engine

46. On a wooden propeller, the pitch is allowed to vary

a. $\frac{3}{16}$ deg.

b. $\frac{5}{32}$ deg.

c. ⅛ deg.
d. ¼ deg.

47. Large-diameter propellers are desirable on
a. high-altitude engines only
b. all engines over 300 hp.
c. supercharged engines
d. geared engines

48. The procedure when balancing a wooden propeller is to
a. sand down the tip of the heavy blade until the correct balance is obtained
b. apply solder to the tipping of the light blade
c. apply shims behind the heavy end
d. shift the clamp rings

49. Windmilling is prevented, on a hydromatic full-feathering propeller, by
a. a mechanical brake operated from the cockpit
b. a hydraulically operated propeller brake
c. by feathering
d. by skillful adjustment of the three-way valve

50. An auxiliary pressure supply is used, on a hydromatic full-feathering propeller,
a. to change from low pitch to high pitch
b. to assure constant r.p.m.
c. for increasing r.p.m. only
d. to feather the blades

ESSAY-TYPE QUESTIONS*

51. What is the purpose of coating the splines, cones, and cone seats with clean engine oil before installing the propeller?

52. Why should the brush cap-assembly be removed before installing or removing a Curtiss controllable propeller from the shaft?

53. What length of bar is required to tighten the retaining nut of a Curtiss controllable propeller?

* Answers are given on p. 252.

54. What voltage is required to operate the motor of the Curtiss controllable propeller?

55. Is the brake of a Curtiss controllable propeller engaged while the motor is operating?

56. How is the specified blade angle of the ground adjustable propeller originally determined?

57. What are the purposes of ring clamps used on a ground adjustable propeller?

58. What is the purpose of the rear cone spacer used on a noncontrollable propeller installation?

59. What is the primary purpose of a controllable propeller?

60. What is the main cause of propeller vibration?

61. What is the greatest cause of propeller failure?

62. What is the purpose of a propeller?

63. Why are the propeller-blade sections thick near the hub?

64. Define the following terms: (*a*) blade angle, (*b*) blade face, (*c*) blade root, (*d*) feathering.

65. What directs the flow of oil to and from the pitch-operating cylinder of a Hamilton Standard two-position propeller?

66. What prevents the barrel from chafing the spider in a Hamilton Standard two-position propeller?

67. What limits the high- and low-pitch settings of the blades on a Hamilton Standard two-position propeller?

68. Where is the base blade-angle setting found on a Hamilton Standard two-position propeller?

69. What is the purpose of the piston lock ring used on a Hamilton Standard two-position propeller?

70. What is the preferred method of checking a propeller for track in the field?

71. Are the halves of a propeller front cone interchangeable?

72. How are raised edges of cuts, scars, and scratches on steel blades treated?

73. Where is prussian blue applied when checking cones for bottoming?

74. What portion of the propeller blade is given an antiglare coating?

75. How is the leading edge of an aluminum-alloy blade treated if it is pitted from normal wear?

KEY TO MULTIPLE-CHOICE QUESTIONS ON PAGE 240

1. *d*	2. *e*	3. *a*	4. *c*	5. *d*	6. *a*
7. *a*	8. *a*	9. *d*	10. *c*	11. *b*	12. *e*
13. *d*	14. *b*	15. *a*	16. *e*	17. *c*	18. *a*
19. *a*	20. *d*	21. *b*	22. *a*	23. *c*	24. *a*
25. *e*	26. *c*	27. *b*	28. *d*	29. *b*	30. *c*
31. *d*	32. *b*	33. *c*	34. *c*	35. *c*	36. *a*
37. *d*	38. *b*	39. *c*	40. *c*	41. *a*	42. *c*
43. *c*	44. *b*	45. *a*	46. *d*	47. *d*	48. *b*
49. *c*	50. *d*				

ANSWERS TO ESSAY-TYPE QUESTIONS ON PAGE 250

51. The purpose of coating the splines, cones, and cone seats with clean engine oil before installing a propeller is to assure proper lubrication and to prevent corrosion. Cup grease or semifluid greases are not used for this purpose. The threads on the propeller shaft are also thoroughly coated with lubricant.

52. In removing or installing a Curtiss controllable propeller, the brush assembly is always removed first from the housing to eliminate any possibility of damage to the brushes.

53. To tighten a retaining nut on a Curtiss controllable propeller, you would use a bar 3 to 3½ ft. long installed through the retaining nut. A force of from 250 to 300 lb. at the end of the bar will properly tighten the nut.

54. The voltage required to operate the motor of a Curtiss controllable propeller is 12 volts. The pitch-control motor is a series-wound, direct-current motor, and has a double field, to provide for rotation in either direction.

55. No. The brake is not engaged while the motor is operating.

56. The blade angle of a ground adjustable propeller is first determined by flight tests. Inasmuch as the blade angle is

not controllable, it is set at the time of assembly for an angle that is fairly efficient for all service conditions.

57. The purpose of the ring clamps on ground adjustable propellers is to hold the blades in the hub.

58. The purpose of a rear cone spacer is to locate properly the propeller on the shaft and to prevent interference with engine cowling.

59. The primary purpose of a controllable propeller is (*a*) to permit the engine to develop full-rated power; (*b*) to permit the propeller blades to operate at the most advantageous blade angle; and (*c*) to permit readjustment of the blade angle to the particular power and altitude conditions.

60. The main cause for propeller vibration is certain irregularities of air flow, such as might be caused by a coolant radiator placed too close to the plane of propeller rotation. The main cause for propeller vibration is the engine power impulses. Vibration, if allowed to continue, will cause complete failure in a few hours' operation. Each engine has a critical range of operation for each type of propeller with which it is combined. Continued engine operation in this critical range must be avoided.

61. The greatest cause of propeller failure is fatigue due to vibration.

62. The purpose of a propeller is to pull the airplane through the air, or to provide the necessary thrust for flight.

63. The sections from 12 to 18 in. from the hub are thick in order to give strength to the propeller and, as a result, deliver little or no thrust.

64. *Blade angle* is the angle between the chord of a section of a propeller blade and a plane perpendicular to the axis of rotation. Deviation from a blade-angle setting as much as 1 deg. above to ½ deg. below may be authorized. A change of 1 deg. in blade angle will affect the engine r.p.m. between 70 to 100 r.p.m.; on geared engines, this will vary with the gear ratio. *Blade face* is the flat side of a propeller blade, similar to the lower surface of an air-foil section. *Blade root*

is the portion of the blade located in the hub. *Feathering* is the term that designates the operation of rotating propeller blades beyond the highest angle required in normal flying to approximate line of flight position that prevents the propeller from windmilling in flight with the engine power completely off.

65. An oil pressure line from the main supply in the engine is connected to a three-way valve, and thence through a collector ring into the interior of the front end of the crankshaft and out into the pitch operating cylinder.

66. A micarta bushing, which fits around the bottom of the spider, prevents the barrel from chafing the spider. Oilite shim plates protect the spider from galling.

67. Propeller stops limit the high- and low-pitch settings of the blades on a Hamilton Standard two-position propeller.

68. A steel counterweight is fastened to the outer face of the bracket by fillister screws. A slot in the counterweight corresponds to the cam in the bracket. It is up and down this slot that the cylindrical extension of the bearing shaft moves. Along one side of this slot is a scale. It has degree graduations, which are stamped during final assembly and correspond to protractor measurements of the blade at the 42-in. station. Toward one end of the slot is a lead fillet on which is stamped the base setting of the blade.

69. The purpose of the lock ring on a Hamilton Standard two-position propeller is to secure the piston. When disengaging the piston lock ring, be sure to remove the cotter pins first. It is good practice to slide the lock ring up on the piston. The propeller should be in the high-r.p.m. (low-pitch) position for removing the cotter pins.

70. The approved method for checking a propeller for track in the field is to attach a fixed point to some part of the airplane so that it touches the blade face near the extreme tip of the blade. Rotate the propeller until the next blade is in the same position and note the distance between the blade face and a fixed point. Repeat the operation for each of the other

blades. This method eliminates blocking the wheels of the airplane, and any movement of the airplane will not change the position of the fixed point relative to the blade face. This method is a field-check method and cannot be considered an accurate check.

71. No. The halves of propeller hub front cones are not interchangeable. When one half is found unserviceable, the other half is disposed of.

72. The raised edges of scars, cuts, scratches, etc., are polished out by hand stoning. The amount of metal removed should be as small as possible. Under no circumstances will any other metal be removed, nor will other tools be used for this purpose. Small shallow dents located on the leading or the trailing edge or near the tip of the propeller blade are of no consequence and therefore do not require repairs.

73. When checking cones for bottoming, apply a thin coating of prussian blue to the inner end face of the front cone. Assemble the front cone on the retaining nut or the piston and firmly tighten the parts. Unscrew the retaining device and see if the blue has been transferred to the ends and the crankshaft. If no such transfer is indicated, clean off the prussian blue, lubricate, reassemble, tighten, and secure the parts. NOTE: Some crankshafts have tapered seats for the rear cones. Such rear cones cannot be moved forward by spacers. If the front cone bottoms on splines of these shafts, the rear cones will be replaced.

74. Antiglare coating is placed on the face side of the propeller blades. This coating extends from the 24-in. station to the tip.

75. Shallow dents located on the leading or the trailing edge or near the tip of the propeller blade are of no consequence and do not need repairs, although they can be smoothly finished off with No. 00 sandpaper.

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